SILVACO

VWF

User's Manual

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Style Conventions		
Font Style/Convention	**Description**	**Example**
•	This represents a list of items or terms.	• Bullet A • Bullet B • Bullet C
1. 2. 3.	This represents a set of directions to perform an action.	To open a door: 1. Unlock the door by inserting the key into keyhole. 2. Turn key counter-clockwise. 3. Pull out the key from the keyhole. 4. Grab the doorknob and turn clockwise and pull.
→	This represents a sequence of menu options and GUI buttons to perform an action.	**File→Open**
`Courier`	This represents the commands, parameters, and variables syntax.	`HAPPY BIRTHDAY`
Times Roman Bold	This represents the menu options and buttons in the GUI.	**File**
New Century Schoolbook Italics	This represents the variables of equations.	$x + y = 1$
Note:	This represents the additional important information.	**Note:** Make sure you save often when working on a manual.

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Chapter 1
Introduction

1.1 What is Virtual Wafer Fab (VWF)

VWF is designed to be used interactively to mirror procedures performed in real wafer fabs and to automate the user-intensive tasks of preparing experiments, running simulations, and analyzing results. This results in a convenient use of process and device simulation tools both in two and three dimensions and the ability to perform large, simulation-based design studies.

1.1.1 Advantages

VWF provides major advantages:

- Greatly reduces the cost of experimentation because you only need this software to perform them.
- Greatly reduces the design cycle time because simulations will complete hours or days, while actual fabrication typically takes weeks or months.

1.1.2 Applications

Here are some of the operations that VWF can perform:

- Studying the effects of process variation on circuit performance
- Experimenting layout variation such misalignment and over/under etch on Device performance
- Synthesis and optimization of inductor design
- Optimization of circuit performance
- Automated calibration
- Optimization of Parasitic interconnect versus circuit performance
- Inductor PDK generation
- SPICE parameter extraction versus process variation

1.2 Features

VWF helps you perform design experimentation efficiently without resorting to third party software. Some of the advanced features provided are described below.

1.2.1 Database

The heart of the VWF system is a structured multi-user database that contains all of the data associated with the design process. The software uses a modern, scalable, SQL-92 based database engine to ensure integrity of your data.

In addition to the SQL-92 database engine, large binary files as generated by simulators are stored in the file system in a central location. All files pertaining to a particular experiment can be browsed, manipulated, and retrieved for visualization by the VWF software.

1.2.2 User-Friendly

Access to or control of the data is provided through comprehensive Graphical User Interface (GUI) technology. It is not required for you to learn any computer specific command syntax or require the use of any other software beyond that provided by VWF.

The results are automatically presented in the form of spreadsheets and graphical charts that require little or no user interaction to extract the desired information.

VWF offers a mechanism to extend the built-in experimental design models. A modern scripting language is offered to implement your own design model.

1.2.3 Experimental Design

The amount of simulations required to cover all possible variations in input values is immense. Modern experimental designs are used to generate combinations of Input Parameters that help maximize the amount of information obtained from a given number of simulations.

VWF generates Split Lot Parameter Values for many of the commonly used experimental design models, including Full and Partial Factorial, Box-Behnken, Composite, and Latin Hypercube.

1.2.4 Optimization

VWF allows you to carry out experiments, where a chosen optimization algorithm is used to vary split parameters so that a defined target is minimized. This allows you to use VWF for automated calibration tasks and to optimize process parameters in a process simulation. Supported optimization algorithms are Levenberg-Marquardt, Genetic Algorithm, and Simulated Annealing to name a few.

1.2.5 Network Execution

A queuing and scheduling system automatically submits simulations for execution on remote machines if they are available. This permits the computing load to be spread across any number of machines on a network. The software supports standardized modern grid computing facilities like Open Grid Scheduler (OGS) or Load Sharing Facility (LSF).

1.2.6 Security Features

VWF supports advanced security features. For security sensitive applications, all data can be held on a central VWF server. It is possible to define privileges such as read, write, or execute on a per user level. Groups can be defined to implement department security profiles. User authentication on the network follows the SASL (Simple Authentication and Security Layer) standard.

1.2.7 Scripting Interface

VWF supports a powerful scripting interface to run JavaScript scripts. In addition to creating your own experimental designs, this can be used to run VWF experiments without the need of the GUI (batch mode).

1.3 Simulators

VWF supports 2D and 3D process and device simulators, SPICE parameter extraction and circuit simulators as well as interconnect parasitic extraction tools.

Chapter 2
Installation

2.1 VWF Variants

The VWF software can be utilized in several ways. Depending on how you use VWF, different installation steps are required. The following shows a brief outline of the different ways of using VWF. This is followed by detailed installation instructions.

Depending on what features of VWF you would like to use, there are four ways you can use VWF:

- File mode - This does not utilize a database at all. Instead, the necessary information to run experiments is kept in files.
- Database mode - A database is utilized to store experiments and results. Execution of experiments takes place either on your local workstation or on a central VWF server. Advanced security strategies are enforced.
- Open Grid Scheduler (OGS) queue - Allows you to utilize an Open Grid Scheduler cluster to run simulations.
- Load Sharing Facility (LSF) queue - Allows you to utilize an LSF cluster to run simulations.

All four variants require you to at least install the VWF TAR file. This step is explained in the next section.

2.2 Installing the VWF TAR file

The VWF software is shipped as a single TAR file, which contains all components of VWF. This TAR file must be untarred in a directory, which is accessible from all machines you would like to run the VWF software from. A suitable location for this is an NFS drive on a dedicated file server. This drive must be mounted on every workstation, which will be able to run the software.

Note: If you plan to also install the database system, then the database must be running on the very same machine where you untar this VWF TAR package. If you want to install the database on a separate machine, you will have to download and install an extra TAR package. Please contact a Silvaco representative for further details.

Note: You can safely untar this package over a previously created Silvaco installation. All packages are versioned so that you can later continue to use the previously installed software even after the untar operation has finished. In case you want to revert to the state before installation of this package, you need to copy the whole install tree into a separate location before you start the untar.

In the following example, the contents of the VWF TAR file are untarred into the `/build/silvaco` directory:

```
[root@lannach root]# cd /build/
[root@lannach build]# mkdir silvaco
[root@lannach build]# cd silvaco
[root@lannach silvaco]# tar xvzf 12113-vwf-2010-00-rh64.tar.gz
bin/acroread
bin/dbinternal
bin/deckbuild
bin/ghostprint
bin/vwf
bin/maskviews
bin/sedit
bin/sflm
bin/sflm_access
bin/sflm_monitord
bin/showid
bin/sipc
bin/gbak
bin/gsec
bin/isql
bin/fbguard
bin/fbmgr
```

```
bin/firebird
bin/smd5sum
bin/srdb
bin/vwf_server
bin/vwf_upgrade
bin/vwf_backup
bin/vwf_restore
bin/spayn
bin/sencrypt
.
.
.
```

The output of the `tar` command was truncated. Many more files as shown here will be displayed on the screen.

2.3 VWF Modes

2.3.1 File Mode

This is the simplest way of running VWF. A big advantage of this mode is that no extra installation steps are necessary. A disadvantage of this mode, however, is that sharing data with other users of your department or company may become slightly more difficult as you need to put the files in a shared location.

You can invoke `vwf` in file mode using:

```
vwf -filemode
```

Note: You have to run every experiment in its own directory. This is because the VWF file mode creates (and removes) uniquely named sub-directories whenever the experiment is started or restarted.

2.3.2 Database Mode

This is the standard mode. It is invoked if you start `vwf` without the `-filemode` option. VWF keeps all experiment related data in a database system and all simulation files in a central directory. VWF is directly built upon a 64-bit relational database system called Firebird to store experiment data. This data includes all the statically entered data as described in Chapter 3 “Using the VWF GUI”, plus the information that is computed during runtime of an experiment. These are the results extracted from simulations. Firebird, originally developed by Borland, is freely available from The Firebird Project.

To utilize this mode, you need to first install the Firebird relational database system. Next, you need to create a specific VWF database in Firebird. This setup will then allow you running simulation jobs directly on your local workstation or on a grid computing environment. One notable difference to filemode is also that experiments are executing in the background. This allows you to close the GUI after the experiment was started. In the simplest case, the background execution takes place on the very same machine where you also run the GUI from.

The default configuration in this mode is to store all simulation result files relative to your UNIX home directory. The full directory of an experiment is as follows:

```
$HOME/vvwf_basedir/<username>/<database_name>/<experiment_name>_10001/
```

where

- `$HOME` is your home directory,
- `username` is the name of your UNIX account,
- `database_name` is the name of the database, which was given when it was created using the SRDB utility, and
- `experiment_name` is the name of the experiment in VWF.

The trailing number (`_10001`) is an automatically chosen sequence number to avoid name clashes.

The first part of the directory (`$HOME/vwf_basedir`) can be configured to point into a different location using the `VWF_BASEDIR` environment variable.

Note: You do not need to change the location of the simulation files unless you want to use either LSF or the Open-Grid-Scheduler (OGS) queuing system.

OGS and LSF will require a location, which is accessible from all machines that are part of the grid.

The VWF background process (`vwf_server`) will log information to a log file. While not normally concerned with log files, they can be helpful in case there is an error condition. The location of the log file defaults to `$HOME/vwf_logs`. It can be changed by using the `VWF_LOGDIR` environment variable.

When any of the `VWF_BASEDIR` or `VWF_LOGDIR` variables are changed, please make sure the change is propagated to all components of VWF. To do so, please set these variables directly in your `.cshrc` or `.bash_profile` startup files, terminate all components of VWF including the `vwf_daemon`, and completely log out of your account. After logging back in and re-starting the VWF, it will indicate that the `vwf_daemon` is being started again as soon you connect to a database.

As an advanced configuration option, you can decide to run the VWF background processes completely isolated on a separate server machine. This makes sense for instance if your workstation is no LSF or OGS submit host. It also helps you to share data between several users as all data are kept on a central server location. Finally, it also allows you to implement a more tight security policy, as simulation files are no longer directly accessible from regular UNIX accounts. No NFS access is needed from the VWF GUI to the server machine. Please proceed directly to "Database Mode – Installing the vwf_daemon on a central VWF server" on page 28 below.

Upgrading from a Previous VWF Install

If you are upgrading from a previous release, it may be necessary to manually stop the `vwf_daemon` after the upgrade. This is because the `vwf_daemon` runs in the background and is not normally stopped when you terminate VWF. Stopping of the `vwf_daemon` is only necessary, however, in case a new `vwf_daemon` version was installed by the upgrade.

If you are upgrading from a 2.10.xx, 2.8.xx, 2.6.xx , 2.4.xx, or 2.2.xx version of VWF, then you need to upgrade the database to version 7 (v7). Upgrading a database is done by using the SRDB utility.

Note: Version numbers for databases evolve in a different numbering scheme as do version numbers for the VWF software. Versions 2.10.0 to 2.10.3 of VWF were based on the version 5 (v5) database schema. 2.10.xx versions of VWF above 2.10.3 use the database schema version 6 (v6). The 2.12.xx series of VWF uses database schema version 7 (v7).

Note: It is advisable to fully backup your existing database before you do the actual upgrade.

To perform a backup of an existing database and all simulation files, you must use the `vwf_backup` utility. This utility is based on the SRDB utility with the notable addition that simulation files are backed up as well. If the tool is invoked without a command-line argument, it prints a short usage message:

```
                              V W F _ B A C K U P
                          Copyright (C) 1984 - 2013
                        Silvaco Inc. All rights reserved

ERROR 2013-03-14 09:38:43,749 option -host missing

ERROR 2013-03-14 09:38:43,749 option -passwd missing

ERROR 2013-03-14 09:38:43,749 option -db missing

ERROR 2013-03-14 09:38:43,749 option -file missing


usage: vwf_backup -host hostname -db database-name -passwd password

     -file output file [-srdb path_to_srdb] [-flags flags_to_srdb]

                       [-properties properties-file][-bd base_directory]

      -srdb  ... select which srdb version to use (default uses srdb from $SILVACO/
                 bin)

      -flags ... pass flags to srdb command (e.g. to select a particular version)

      -properties ... take all options from a properties file (all other options are
                      ignored)


e.g. : vwf_backup -host lannach -db vwf_test -passwd simucad

                              -file backup_test_20081210.tgz


         This will attempt to make a backup of database vwf_test

         on server lannach and store the dump together with all

         result files in a file called backup_test_20081210.tgz.

         The password used for the connection is simucad.


or   : vwf_backup -srdb /build/silvaco/bin/srdb -flags "-V 10.0.11.R"

                              -host lannach -db vwf_test -passwd simucad

                              -file backup_test_20081210.tgz


         Same as above except that srdb is taken from /build/silvaco/bin

         rather than from $SILVACO/bin, and that version 10.0.11.R is executed

         instead of the default version.


or   : vwf_backup -properties properties.config

       This will take all options from the properties file

       instead of the commandline
```

Below an example of how a database called vwf_demo2 can be backed up into a file called vwf_demo2.tgz.

```
[root@lannachn ~]# vwf_backup -host lannachn -passwd simucad -db vwf_demo2
-file vwf_demo2.tgz

                                V W F _ B A C K U P
                              Copyright (C) 1984 - 2013
                            Silvaco Inc. All rights reserved

INFO  version info:vwf_backup 2.12.0.R (Thu Mar 14 15:32:53 CET 2013)
INFO  Backing up simulation files from directory "/build/silvaco/var/
vwf_base_local/vwf_demo2" to file:vwf_demo2.tgz
```

The runtime output indicates that the backup succeeded.

Both the simulation result files and the database dump are put into the file named vwf_demo2.tgz.

The created file (vwf_demo2.tgz) can later be used to restore the database and all created simulation files. This will be important in case something goes wrong during the upgrade process.

After creating a backup, invoke the SRDB utility and run the upgrade script as shown in the example below.

```
thomasb@lannachn$ srdb

                                        S R D B

                              Version:  srdb 2.4.22.R (2013-03-15T15:29:08)

                                    Copyright (c) 1984 - 2013
                                  Silvaco, Inc.  All rights reserved

                        ======================================================

SRDB >login lannachn

Password for server lannachn :

SRDB lannachn >upgrade vwf_demo2 VWF 6 7

LIBRARIES  /build/silvaco/lib/firebird/1.5.2.R/x86_64-linux/lib:/build/silvaco/lib/
firebird/1.5.2.R/x86_64-linux:/build/grid/lsf/7.0/linux2.6-glibc2.3-x86_64/lib:/
usr/lib:/lib:/usr/openwin/lib:/build/silvaco/lib/support/x86_64-linux:/build/sil-
vaco/lib/support/i386-linux

Use CONNECT or CREATE DATABASE to specify a database

Database vwf_demo2 type VWF upgraded from version 6 to 7 on server lannachn.

SRDB lannachn >
```

The last line of the runtime output of this example indicates that the upgrade was successful.

The database can now be accessed by VWF version 2.12.0 or greater only. It is no longer possible to open the database using an older version of VWF. There is also no way of downgrading a previously upgraded database. If you want to access the data using an older version of VWF, you must use the VWF version, which actually corresponds to the database schema. If there is an error during an upgrade and you want to go back, use the `vwf_restore` utility to restore the state of the database to when you first ran the upgrade. Please note that– as a safety measure–the restore utility does not overwrite any existing data in your system. Therefore, you must manually remove both the database (using SRDB) and the simulation files before a restore will succeed.

Below, the output of the SRDB utility is shown for the case where you need to upgrade your system over several schema versions. As an example, a database called `vwf_v2` is upgraded from version 2 to version 7:

```
SRDB lannachn >upgrade vwf_v2 VWF 2 7

LIBRARIES  /build/silvaco/lib/firebird/1.5.2.R/x86_64-linux/lib:/build/silvaco/lib/
firebird/1.5.2.R/x86_64-linux:/build/grid/lsf/7.0/linux2.6-glibc2.3-x86_64/lib:/
usr/lib:/lib:/usr/openwin/lib:/build/silvaco/lib/support/x86_64-linux:/build/sil-
vaco/lib/support/i386-linux

Use CONNECT or CREATE DATABASE to specify a database

LIBRARIES  /build/silvaco/lib/firebird/1.5.2.R/x86_64-linux/lib:/build/silvaco/lib/
firebird/1.5.2.R/x86_64-linux:/build/grid/lsf/7.0/linux2.6-glibc2.3-x86_64/lib:/
usr/lib:/lib:/usr/openwin/lib:/build/silvaco/lib/support/x86_64-linux:/build/sil-
vaco/lib/support/i386-linux

Use CONNECT or CREATE DATABASE to specify a database


                 KEY_OUT ERR_OUT

==================== ================

                     6071 <null>



                 USERKEY ERROR

==================== ======

                       -1 USEDN


LIBRARIES  /build/silvaco/lib/firebird/1.5.2.R/x86_64-linux/lib:/build/silvaco/lib/
firebird/1.5.2.R/x86_64-linux:/build/grid/lsf/7.0/linux2.6-glibc2.3-x86_64/lib:/
usr/lib:/lib:/usr/openwin/lib:/build/silvaco/lib/support/x86_64-linux:/build/sil-
vaco/lib/support/i386-linux

Use CONNECT or CREATE DATABASE to specify a database

LIBRARIES  /build/silvaco/lib/firebird/1.5.2.R/x86_64-linux/lib:/build/silvaco/lib/
firebird/1.5.2.R/x86_64-linux:/build/grid/lsf/7.0/linux2.6-glibc2.3-x86_64/lib:/
usr/lib:/lib:/usr/openwin/lib:/build/silvaco/lib/support/x86_64-linux:/build/sil-
vaco/lib/support/i386-linux

Use CONNECT or CREATE DATABASE to specify a database
```

```
LIBRARIES  /build/silvaco/lib/firebird/1.5.2.R/x86_64-linux/lib:/build/silvaco/lib/
firebird/1.5.2.R/x86_64-linux:/build/grid/lsf/7.0/linux2.6-glibc2.3-x86_64/lib:/
usr/lib:/lib:/usr/openwin/lib:/build/silvaco/lib/support/x86_64-linux:/build/sil-
vaco/lib/support/i386-linux

Use CONNECT or CREATE DATABASE to specify a database

Database vwf_v2 type VWF upgraded from version 2 to 7 on server lannachn.

SRDB lannachn >
```

Please note the last line, which indicates that the database was properly upgraded from version 2 to version 7.

Installing the Firebird Database System

This is the default mode of operation where all your simulation jobs are run on your local workstation. You will need to install firebird when you want to run VWF in database mode.

Note: If you already have installed firebird with a different Silvaco software package (e.g., Utmost IV), then you do not need to redo this step. Please proceed directly to "Creating a VWF Database" on page 23.

Note: All firebird (not SRDB) commands described in this manual need to be run as `root` or they will fail.

Firebird has been copied onto your hard disk when you untarred the VWF software from the VWF tar package (see Section 2.2 "Installing the VWF TAR file"). After the files have been untarred, you must install firebird. To do this, invoke the firebird script as follows:

```
[root@lannach ~]# /build/silvaco/bin/firebird -install
Running s_install version: 2.0.3.R  please wait...


Currently 921944 KB free in /tmp (>= 8000)


Preparing to install the Firebird Database Server.
This procedure will modify or create the following system files:


          /etc/rc.d/init.d/firebird


Backups will be created in /var/tmp/s_install.bak
before any files are modified.
Run '/build/silvaco/etc/s_install -rm-bak' or
'/var/tmp/s_install.bak/remove' to remove backup files.


Do you wish to proceed? [y|n] y


Using    database    location    /build/silvaco/var/srdb    owned    by    host
lannach.Silvaco.com (10.72.5.1)


Configuring /build/silvaco/var/srdb ... done.
```

```
Verifying permissions ... done.
Installing servers in init.d ...
Installation done.
Starting and verifying servers ...
LIBRARIES  /build/silvaco/lib/firebird/1.5.2.R/x86_64-linux/lib:/build/silvaco/
lib/firebird/1.5.2.R/x86_64-linux:/build/silvaco/lib/firebird/1.5.2.R/x86_64-
linux/lib:/build/silvaco/lib/firebird/1.5.2.R/x86_64-linux:/usr/lib:/lib:/usr/
openwin/lib:/build/silvaco/lib/support/x86_64-linux:/build/silvaco/lib/support/
i386-linux:/usr/lib:/lib:/usr/openwin/lib:/build/silvaco/lib/support/x86_64-
linux:/build/silvaco/lib/support/i386-linux
Verification done.


FIREBIRD installation completed successfully.
```

After that, firebird has been successfully installed and databases can be created in the `/build/silvaco/var/srdb` directory by using the SRDB utility.

Starting/Stopping Firebird

It may be necessary to stop the database system for maintenance. In this case, you can stop the firebird server by using:

```
/build/silvaco/bin/firebird -stop
```

You can later re-start firebird again by using:

```
/build/silvaco/bin/firebird -start
```

Note: Firebird is stopped and started automatically whenever you reboot your system.

Note: Starting and stopping the firebird server requires `root` privileges.

De-Installing Firebird

To de-install firebird from your system, please use the following command:

```
/build/silvaco/bin/firebird -deinstall
```

This will undo what has been done with `firebird -install` but will not remove the databases from your system. You will have to remove database files from directory `$SILVACO/var/srdb` or remove the directory altogether. When you do a `-deinstall` followed by a `-install`, the same databases that were available before the `-deinstall` will be available after the `-install` again.

Note: Uninstalling the firebird server requires `root` privileges.

Creating a VWF Database

Some system and database administration work will be required to setup and maintain the database system for VWF. VWF databases can coexist with Utmost IV databases on the same firebird server. You do need to create at least one separate VWF database. To create a VWF database, use the SRDB utility. The following gives a short description of how to use this utility. See the SRDB User's Manual for more information.

First, invoke the SRDB command-line utility. Make sure you have an SRDB version of 2.4.22.R or higher. You don't need `root` privileges to run any of the SRDB commands described in this manual.

```
thomasb@lannachn$ srdb


                                    S R D B


                  Version:  srdb 2.4.22.R (2013-03-15T15:33:57)


                              Copyright (c) 1984 - 2013
                            Silvaco, Inc.  All rights reserved


=======================================================

SRDB >
```

Next, you need to connect to a running database server. In this example, this is the same machine from where SRDB is invoked (`lannachn`):

```
SRDB >login lannachn

Password for server lannachn :

lannachn >
```

The prompt changes from `SRDB >` to `lannachn >` to indicate a successful login. There is an interactive help available within the SRDB utility, which can be invoked anytime by typing `help`. The output of the `help` command is context sensitive. It also depends on whether you are logged into a server or connected to a database.

Note: The default password for a database server is `simucad`.

```
SRDB lannachn >help


Available Commands

==================


list databases

connect    <database_name>
```

```
backup     <database_name> <backup_file_name> [overwrite]
backup_all <target_directory> [overwrite]

create        <database_name>  <database_type>  [<target_directory>
[<database_version>] ]
create     accutools
delete     <database_name>
disable    <database_name>
enable     <database_name>
restore    <backup_file_name> <database_name> [<target_directory>]
upgrade      <database_name>  <database_type>  <old_version_number>
<new_version_number>

exit
quit

SRDB lannachn >
```

You can use the `list` command to obtain a list of all databases already existing on the server:

```
SRDB lannachn >list

You are logged in to server lannachn.

Available Databases
===================

Name               Type  Version Number  Location

baseline_2012      VWF   4               /build/silvaco/var/srdb/
baseline_2012.fdb
tutorial           VWF   4               /build/silvaco/var/srdb/
tutorial.fdb
vwf                VWF   6               /build/silvaco/var/srdb/
vwf.fdb
vwf_demo2          VWF   7               /build/silvaco/var/srdb/
vwf_demo2.fdb
vwf_v2             VWF   7               /build/silvaco/var/srdb/
vwf_v2.fdb
```

```
vwf_v5              VWF   5              /build/silvaco/var/srdb/
vwf_v5.fdb
vwf_v5_up           VWF   6              /build/silvaco/var/srdb/
vwf_v5_up.fdb
vwf_v5_upgraded     VWF   6              /build/silvaco/var/srdb/
vwf_v5_upgraded.fdb
vwf_v6              VWF   6              /build/silvaco/var/srdb/
vwf_v6.fdb
vwf_v6_test         VWF   6              /build/silvaco/var/srdb/
vwf_v6_test.fdb
vwf_v6_tpb          VWF   6              /build/silvaco/var/srdb/
vwf_v6_tpb.fdb
vwf_v6_upgraded     VWF   7              /build/silvaco/var/srdb/
vwf_v6_upgraded.fdb


SRDB lannachn >
```

To delete a database, use the following command:

```
SRDB lannachn >delete vwf

LIBRARIES    /build/silvaco/lib/firebird/1.5.2.R/x86_64-linux/lib:/
build/silvaco/lib/firebird/1.5.2.R/x86_64-linux:/build/grid/lsf/
7.0/linux2.6-glibc2.3-x86_64/lib:/usr/lib:/lib:/usr/openwin/lib:/
build/silvaco/lib/support/x86_64-linux:/build/silvaco/lib/support/
i386-linux

Use CONNECT or CREATE DATABASE to specify a database

Database vwf deleted from server lannachn.

SRDB lannachn >
```

To create a new VWF database, use:

```
SRDB lannachn >create vwf VWF /build/silvaco/var/srdb

Database creation. Database version not specified. Defaulting to 7.


LIBRARIES    /build/silvaco/lib/firebird/1.5.2.R/x86_64-linux/lib:/
build/silvaco/lib/firebird/1.5.2.R/x86_64-linux:/build/grid/lsf/
7.0/linux2.6-glibc2.3-x86_64/lib:/usr/lib:/lib:/usr/openwin/lib:/
build/silvaco/lib/support/x86_64-linux:/build/silvaco/lib/support/
i386-linux

Use CONNECT or CREATE DATABASE to specify a database


              KEY_OUT ERR_OUT
==================== ================

                6071 <null>
```

```
Database vwf created as /build/silvaco/var/srdb/vwf.fdb on server
lannachn.

SRDB lannachn >
```

This will create a VWF database named `vwf`. The output should be similar to the one shown above. Now, connect to the new database as follows:

```
SRDB lannachn >connect vwf

SRDB lannachn [vwf] >
```

The prompt will change again to indicate the connection to the database was successful. Finally, create a user in the new database. The command below will create a user called `thomasb` with a password called `thomasb`. Note that the password is the second argument to the `create user` command.

```
SRDB lannachn [vwf] >create user thomasb thomasb

User thomasb created successfully.


SRDB lannachn [vwf] >
```

To print the list of active users on this database, you can use the following command:

```
SRDB lannachn [vwf] >list users


Users

=====


User Name : admin     Status : NORMAL    Groups :

User Name : superuser Status : SUPERUSER Groups :

User Name : thomasb   Status : NORMAL    Groups :
```

`SRDB lannachn [vwf] >`Here, three users are displayed. The first entry – `admin` – was created when the VWF database was created using the `create` command above. This user is the VWF administrator and can be used to modify the security settings for all objects in the VWF database independent from their ownership. The second user is the SRDB internal `superuser`. This is not a VWF specific user. It does not have any function in the VWF system. Please consult the SRDB manual for more details on that user. Finally, the third user – `thomasb` – is the one that was created using the `create user` command above.

Now, terminate the SRDB utility by typing `quit` or use `exit` several times to go through the different connection levels.

```
SRDB lannachn [vwf] >exit

SRDB lannachn >exit

SRDB >quit

thomasb@lannachn$
```

You are now ready to start the VWF software.

In database mode, you can actually close the VWF while experiments are running. When you start an experiment, VWF starts a background job for you, which will take care of executing the experiment.

Database Mode – Installing the vwf_daemon on a central VWF server

You can opt to run all experiments on a central VWF server. This allows you to completely separate the VWF GUI from the VWF job execution module. This enables you to utilize an Open Grid Scheduler or LSF cluster when your workstation does not have direct access to the grid (is no submit host). This mode also does not store the simulation result files on your workstation but keeps all files on the central server instead. No access to server directories (e.g., using NFS) is necessary from your workstation in this mode.

The server side is completely separated from the GUI, which will normally run on a different workstation and which can be closed after an experiment was started. As soon an experiment is started, processes are created on the server and on the available grid computing environment. These processes run under a configured user id. A regular VWF user does not need UNIX rights to access data owned by that user. Instead, control over all data both database as well as files (simulation results) is controlled solely by the VWF security system. Server processes are created (and killed) by the `vwf_daemon` process, which must be installed prior to running VWF.

To install the `vwf_daemon`, you need to run `"vwf -install"`. This will prompt for the user ID to use as well as for a directory to store the simulation result files. It is suggested to create a separate user (e.g., `vwf_user`) for that purpose. The user must be available on all machines, which are part of the cluster environment, but not necessarily on the user's workstation that is used to run the GUI.

The command `"vwf -install"` will also install the firebird database system. Therefore, a separate `"firebird -install"` is not necessary if the `vwf_daemon` is being installed.

Note: In your VWF preferences, you have to change the execution host from the default (`"localhost"`) to match the central server.

Note: If the firebird system has already been installed previously, then it is not installed again by this step.

2.3.3 Single Machine Queue Mode

This mode allows you to run simulation jobs on the machine, which also runs the VWF software (i.e., the machine where you started `vwf`) and is the default queuing mode. It can be

used both in file mode and in database mode. The queue mode is defined in the preferences panel of the VWF software. The single machine queue offers three options to configure. The first option is the maximum number of jobs, which can execute at the same time. The second option is a load limit, which defines a maximum load, which should not be exceeded (Figure 4-14). The load limit is useful when the machine is also used to run jobs outside VWF. In this case, externally run jobs will increase the load limit of the system, which results in less jobs being started from VWF. Finally, the third option is the nice increment level. All processes started by the local queue will have their nice level incremented by the value given in this setting.

Note: When you start jobs outside VWF, it will take a while until the configured load limit will be noticeable. This is because VWF does not actively terminate running jobs if a limit is exceeded but avoids starting new jobs instead. The same is true if you change the load limit during runtime.

2.3.4 DRMAA mode

This mode allows you to run simulation jobs on a cluster of workstations. DRMAA stands for Distributed Resource Management Application API and defines a standard to interface a grid computing facility. The DRMAA queuing system can be used both in file mode and in database mode. You must select this mode if you want to utilize a grid computing environment.

This version of VWF supports two flavors of cluster systems. One is the open source product Open Grid Scheduler (OGS), and the other is the commercially available Load Sharing Facility (LSF).

Note: There is a history of open source grid software supported from VWF. The formerly open source package called Sun Grid Engine is no longer in the open source. Instead, a commercial product called Oracle Grid Engine (OGE), which is based on the Sun Grid Engine is available from Oracle. Additionally, there is the Open Grid Scheduler, which is also based on Sun Grid Engine but is available in the open source.

Note: VWF supports all three flavors: the original 6.2u5 version of Sun Grid Engine, the newer Oracle Grid Engine, and the Open Grid Scheduler.

The VWF tar package contains a version of the Open Grid Scheduler. This is available from the common sub directory of VWF. Please consult the installation instructions given in the Appendix B “Queuing VWF On The Oracle/SUN Grid Engine/ Open Grid Scheduler” on how to install an Open Grid Scheduler cluster system.

Chapter 3
Using the VWF GUI

3.1 Overview

This chapter gives an overview of the Graphical User Interface (GUI) components of the VWF software. All components are explained by means of screen-shots and descriptions. The screen-shots were prepared on the Linux operating system and the KDE window manager.

3.2 Examples Shipped with VWF

VWF comes with a set of examples for you to browse. Depending on the mode of operation, there are three ways you can access these examples. The first method uses the `vwf_restore` command to create a whole database containing (only) the examples and a user called `demo`. The second method allows you to load the examples into an existing database. The third method allows you to open examples individually in filemode. Please note that in order to keep the examples small and loading times short, they do not contain any result files.

3.2.1 Creating the vwf_examples Database

To create the database, please issue the following command:

```
vwf_restore -host lannach -passwd simucad vwf_examples.tgz
```

This command will create a database called `vwf_examples`, which contains a single user called `demo` (password `demo`). When connected to this database (see below for a description of how to do this), you will find a single directory called examples, which contains the shipped examples.

The command may issue a warning as follows about the base directory having changed:

```
Changing experiment base directories of imported DB from:/build/
silvaco/var/vwf_base/vwf_examples to:/site/alpha/var/vwf_base
vwf_examples
```

The warning indicates that the base directory at the time the file was created is different from the base directory on your site. You can safely ignore this warning here.

The file `vwf_examples.tgz` can be found in the examples section of your vwf install tree. Depending on where you installed vwf, this is typically found at

```
/build/silvaco/examples/vwf/<version>/vwf_examples.tgz
```

Please note that this method of loading examples will only succeed on the machine where the `vwf_daemon` was installed. If you're not using the `vwf_daemon`, use the following method.

3.2.2 Loading Examples into an Existing Database

You must use the **Load Examples** menu entry of the **Help** menu found in the VWF Explorer window. Please note that this will create a directory called examples in your database. In case this directory already exists, you must first remove or rename it or you will get an error message.

3.2.3 Opening Examples in filemode

When you're using filemode, you can choose to directly open an example from the main dialog that opens after you started VWF using the `-filemode` option. See Figure 5-53.

3.3 Main GUI components

VWF is comprised of the following three main components:

- **Main Window** – This is the first component you are confronted with. You can manage several databases and open project project from a given database.
- **The Experiment Editor** – This component opens when you edit an existing or create a new experiment.
- **The Deck Editor** – This is a part of the experiment editor but realized as a separate application.

The three components will be presented in detail in the following sections.

3.3.1 Main Window

When starting VWF, the Main VWF Window will appear (see Figure 3-1). This is the main entry point to VWF. Throughout this manual, it will also be called Explorer since it allows you to browse through and open all experiments stored on a given database.

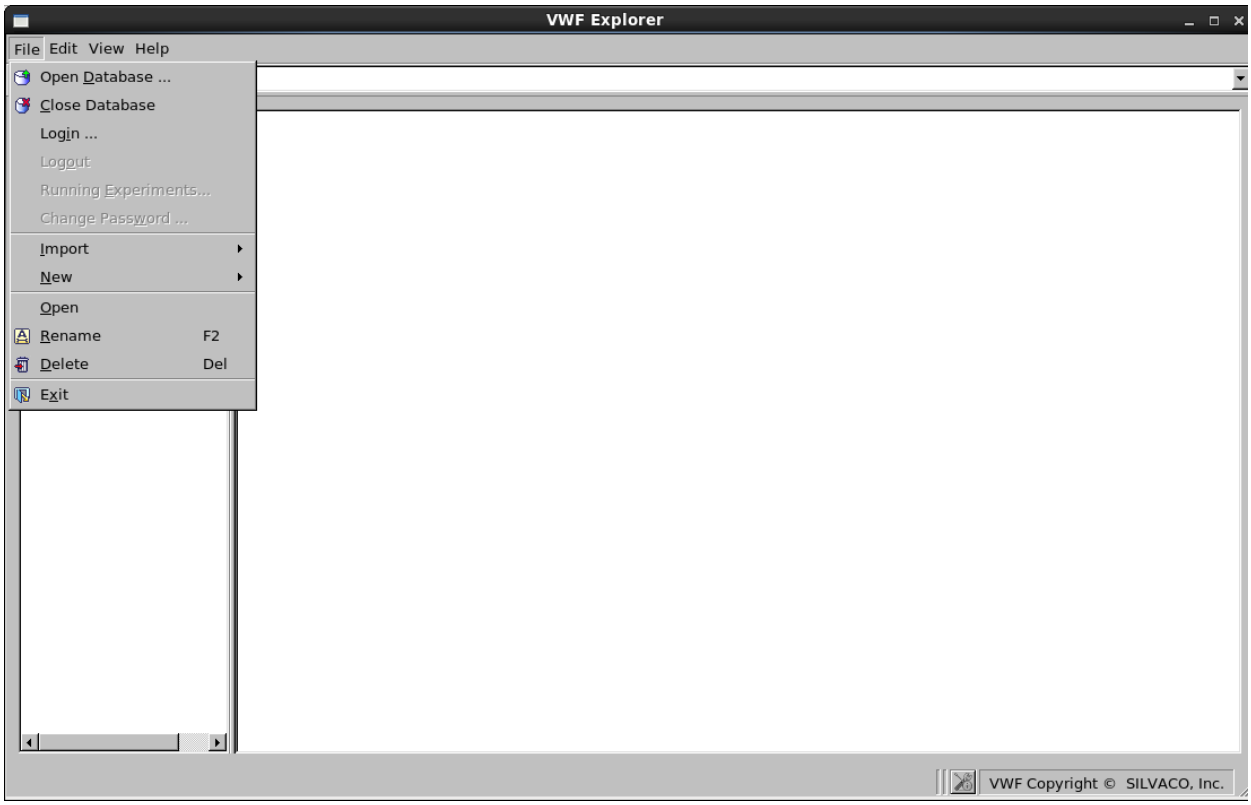


Figure 3-1 Main VWF Window

When starting VWF for the first time, you must first open a database connection. To do this, select **File→Open Database**. The Database dialog will open and ask you to select an available database (see Figure 3-2). Only Silvaco VWF databases, which have been previously installed using the SRDB utility, will be listed.

Note: An arbitrary number of databases can be installed on a given host and that several hosts are supported by both VWF and the SRDB utility.

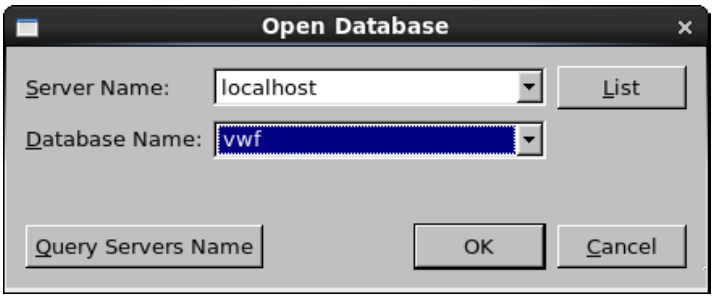


Figure 3-2 Opening a Database

Once you select a database, close the dialog by clicking on the **OK** button. The left pane of the Main Window will look similar to Figure 3-3. In this example, a database named `vwf` on host `localhost` was added. More databases can be added to the Main Window by repeating the **Open Database** step. Once added, a database will not be removed but will be available after restarting the VWF software. The list of added databases is stored persistently in a VWF configuration file in your home directory. Thus, you will not have to re-add your own databases every time you use the software.

Figure 3-3 depicts the popup dialog to enter the password. This dialog is opened upon double-clicking on a database entry. To connect to a database, enter a valid username and password. When selecting **OK** or hitting Enter, the dialog is closed and an attempt is made to connect to the database.

Note: Users must be created separately for every database using the SRDB utility.

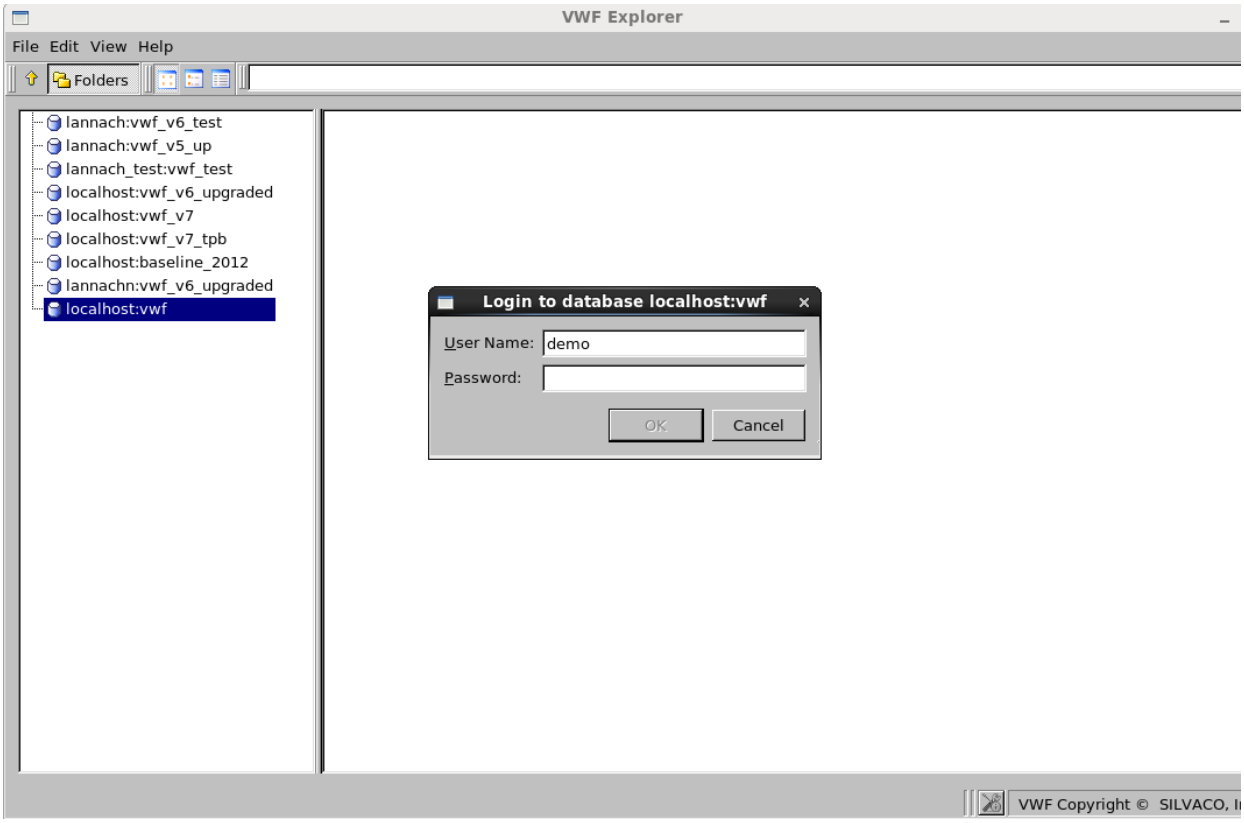


Figure 3-3 Main Window with added VWF Databases

Figure 3-4 shows the scenario after a successful login to the database `vwf` on host `localhost`. VWF is now ready to explore experiments stored in this database. The connection to the database remains open until you either log out manually or close the application. Experiments can be organized hierarchically by means of using directories. In Figure 3-4, the left pane shows a directory named `MOSFET`, which contains a base deck called `base_deck` and two experiments `Exp01` and `Exp02`, which are based on `base_deck`. The handling of experiments follows VWF 1.xx in that several experiments can be based on one base deck.

The bottom of Figure 3-4 displays status information. Starting from the left most entry the information shown is the user name (`demo`) followed by the amount of disk space remaining (Free Space 407.7GB) followed by the "tool version" button ( ) and the copyright message. The disk space is displayed in red color in case the remaining space drops below a configurable limit. The limit can be configured in the preferences panel of VWF. Please see Chapter 4 "Customizing VWF – Preferences Panel" and Figure 4-13.

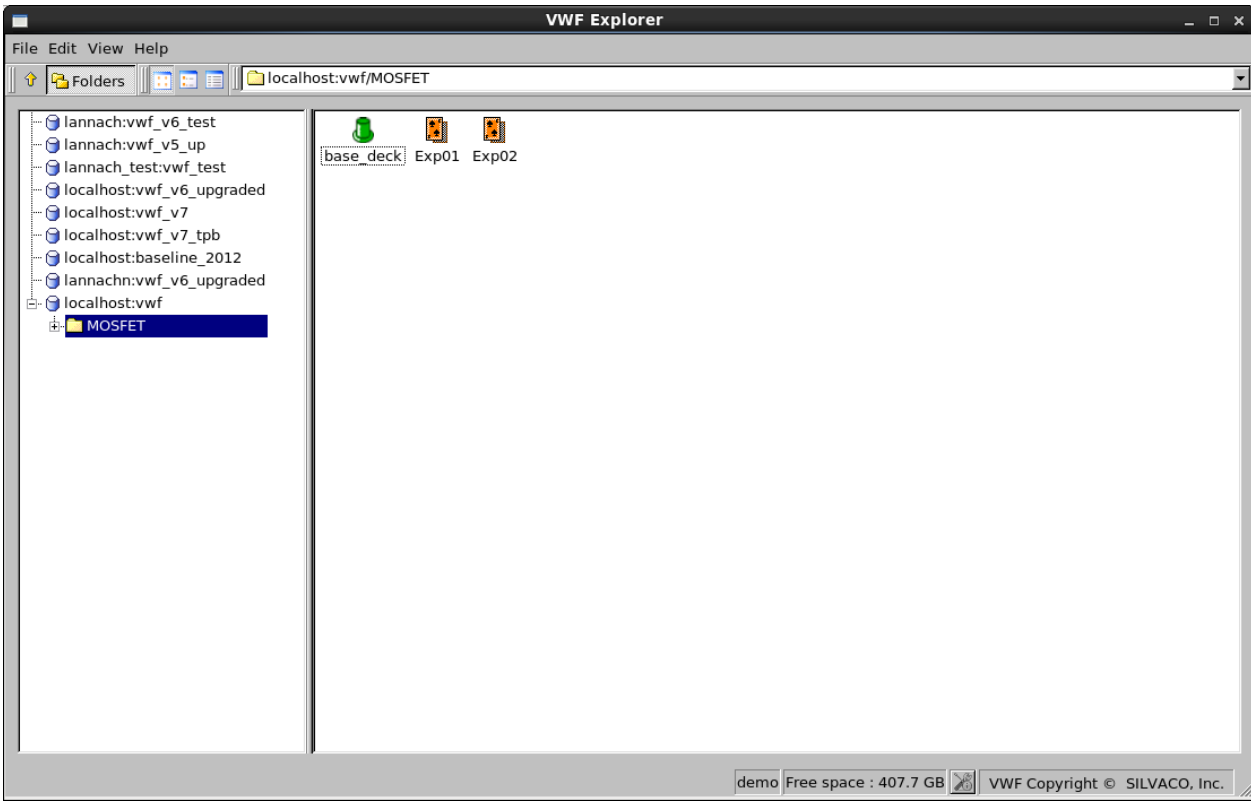


Figure 3-4 Main Window after successful login

Note: Any given directory may only contain a single base deck.

The is used to indicate selected version numbers for tools like, TonyPlot, SPAYN, DeckBuild, or others. Figure 3-5 displays the information when the button is clicked. In this case, a SPAYN version of 2.12.0.R and a DeckBuild version of 4.0.0.C was selected. Please see Chapter 4 "Customizing VWF – Preferences Panel" on how to change version numbers for tools.

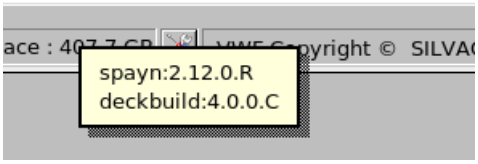


Figure 3-5 Tool Version Information

Figures 3-6 and 3-9 show the Main Window with the folders pane hidden. This can be achieved by clicking on the **Folders** button of the window. The **Folders** button acts as a toggle switch. Thus, the folders will reappear by clicking the button again.

In Figure 3-9, an additional filter was applied to adjust the view of the main pane. Here, only experiments (but not base decks) are shown.

Figure 3-6 Main Window – hiding folders

In case an experiment is highlighted, the description of that experiment is displayed if available. Figure 3-7 displays the main screen with experiment **vwfex02** highlighted. The description pane is only visible if an experiment is highlighted. The contents of the pane are updated whenever you highlight a different experiment. The description pane is available regardless of the tree view or any defined filters.

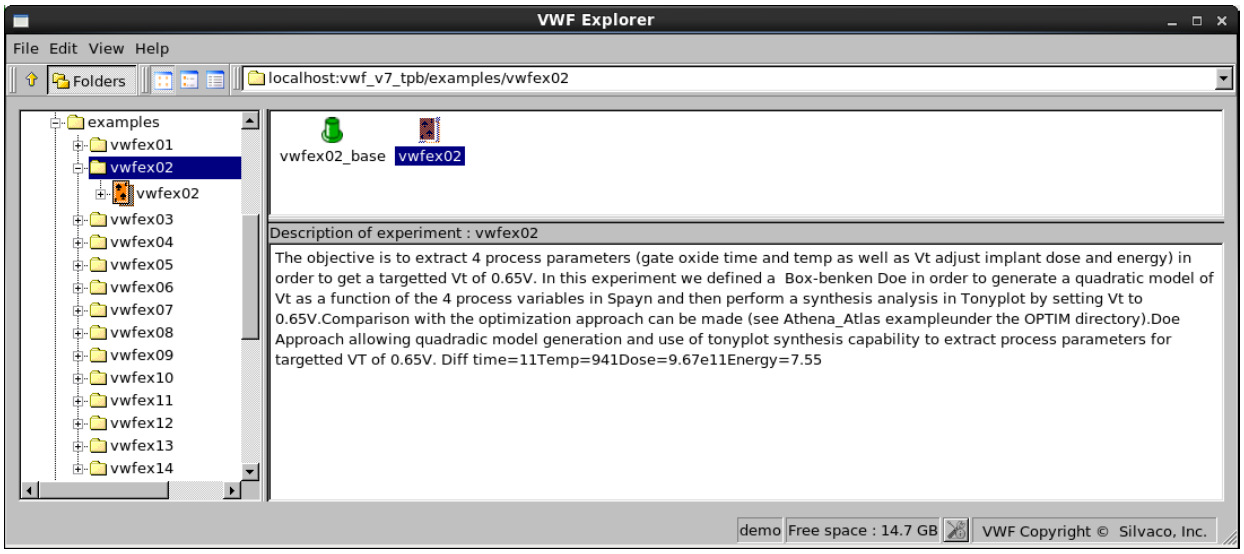

VWF Explorer
File Edit View Help
Folders
localhost:vwf_v7_tpb/examples/vwfex02
examples
vwfex01
vwfex02
vwfex02
vwfex03
vwfex04
vwfex05
vwfex06
vwfex07
vwfex08
vwfex09
vwfex10
vwfex11
vwfex12
vwfex13
vwfex14
vwfex02_base
vwfex02
Description of experiment : vwfex02
The objective is to extract 4 process parameters (gate oxide time and temp as well as Vt adjust implant dose and energy) in order to get a targetted Vt of 0.65V. In this experiment we defined a Box-benken Doe in order to generate a quadratic model of Vt as a function of the 4 process variables in Spayn and then perform a synthesis analysis in Tonyplot by setting Vt to 0.65V.Comparison with the optimization approach can be made (see Athena_Atlas exampleunder the OPTIM directory).Doe Approach allowing quadradic model generation and use of tonyplot synthesis capability to extract process parameters for targetted VT of 0.65V. Diff time=11Temp=941Dose=9.67e11Energy=7.55
demo
Free space : 14.7 GB
VWF Copyright © Silvaco, Inc.

Figure 3-7 Main Window – description pane

Figure 3-8 displays the description pane for the case where the folders are hidden (similar to Figure 3-6 but with an experiment being highlighted).

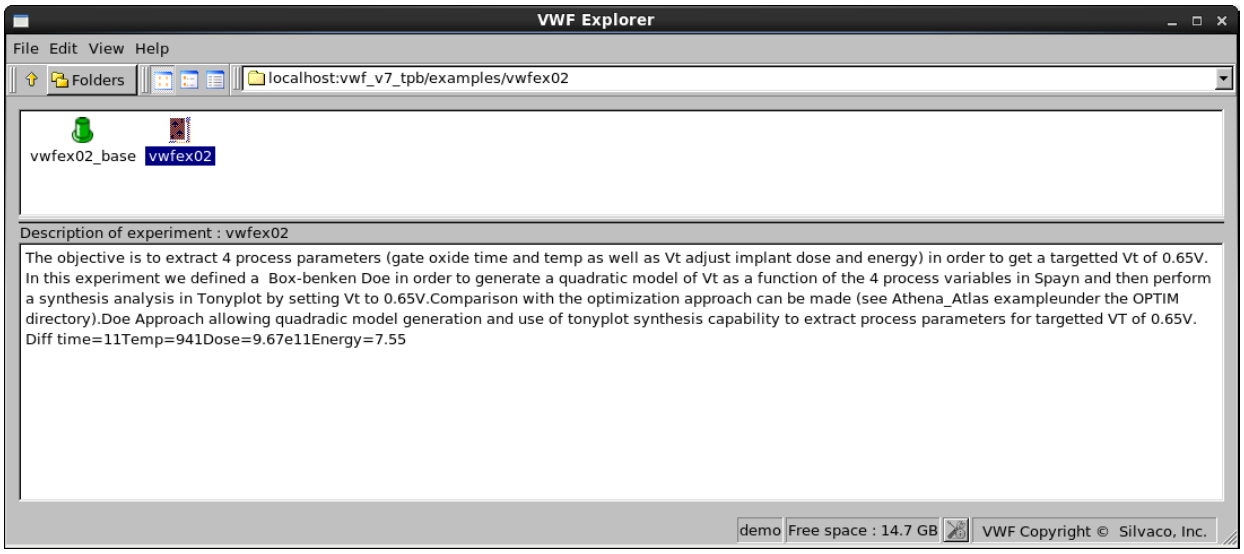

VWF Explorer
File Edit View Help
Folders
localhost:vwf_v7_tpb/examples/vwfex02
vwfex02_base
vwfex02
Description of experiment : vwfex02
The objective is to extract 4 process parameters (gate oxide time and temp as well as Vt adjust implant dose and energy) in order to get a targetted Vt of 0.65V. In this experiment we defined a Box-benken Doe in order to generate a quadratic model of Vt as a function of the 4 process variables in Spayn and then perform a synthesis analysis in Tonyplot by setting Vt to 0.65V.Comparison with the optimization approach can be made (see Athena_Atlas exampleunder the OPTIM directory).Doe Approach allowing quadradic model generation and use of tonyplot synthesis capability to extract process parameters for targetted VT of 0.65V. Diff time=11Temp=941Dose=9.67e11Energy=7.55
demo
Free space : 14.7 GB
VWF Copyright © Silvaco, Inc.

Figure 3-8 Main Window – description pane (disabled tree view)

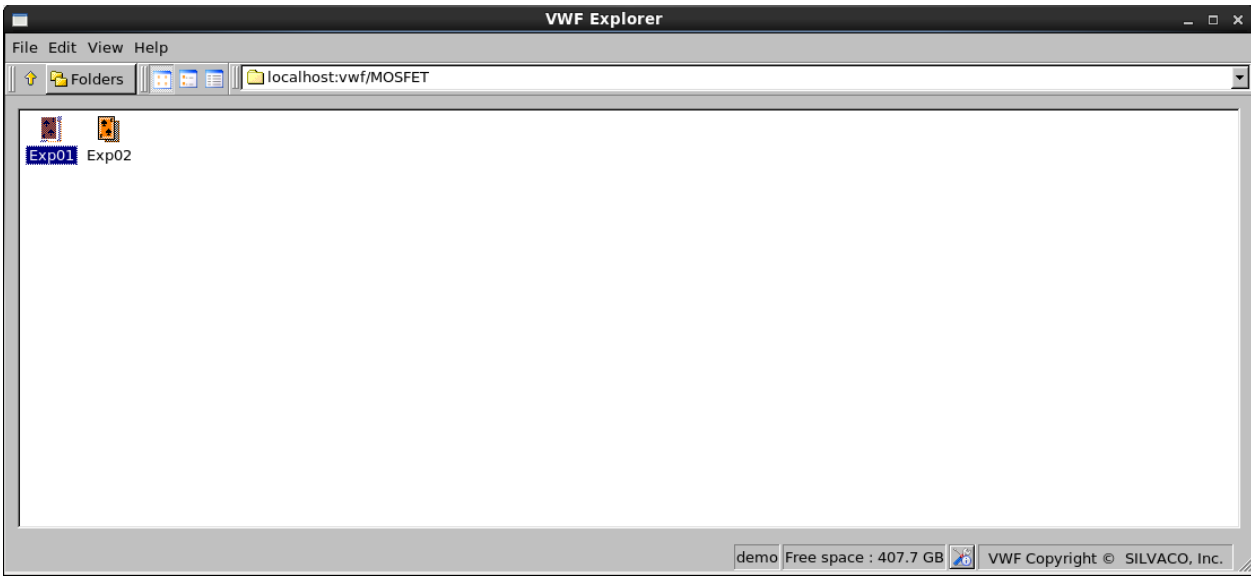


Figure 3-9 Main Window – using filters

Figure 3-10 shows the use of the breadcrumbs portion of the Main Window. The breadcrumbs part is located at the top of the window and can be used to quickly change directories.

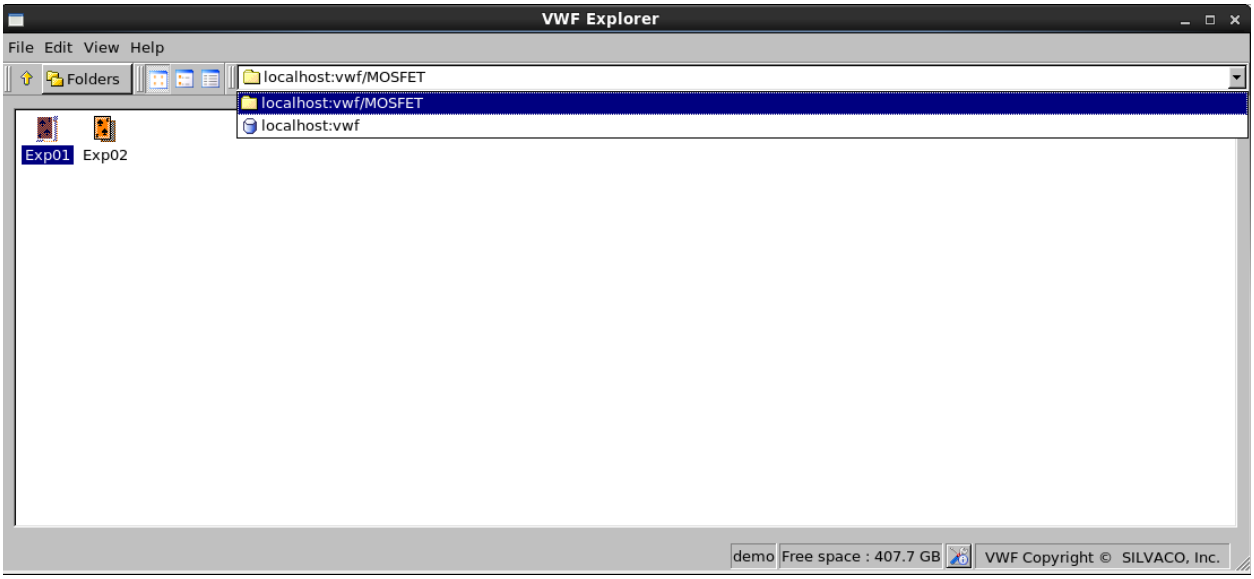


Figure 3-10 Main Window – using breadcrumbs

Figure 3-11 shows how the **File** menu has changed after a successful login. Entries to manipulate experiments and directories have been added.

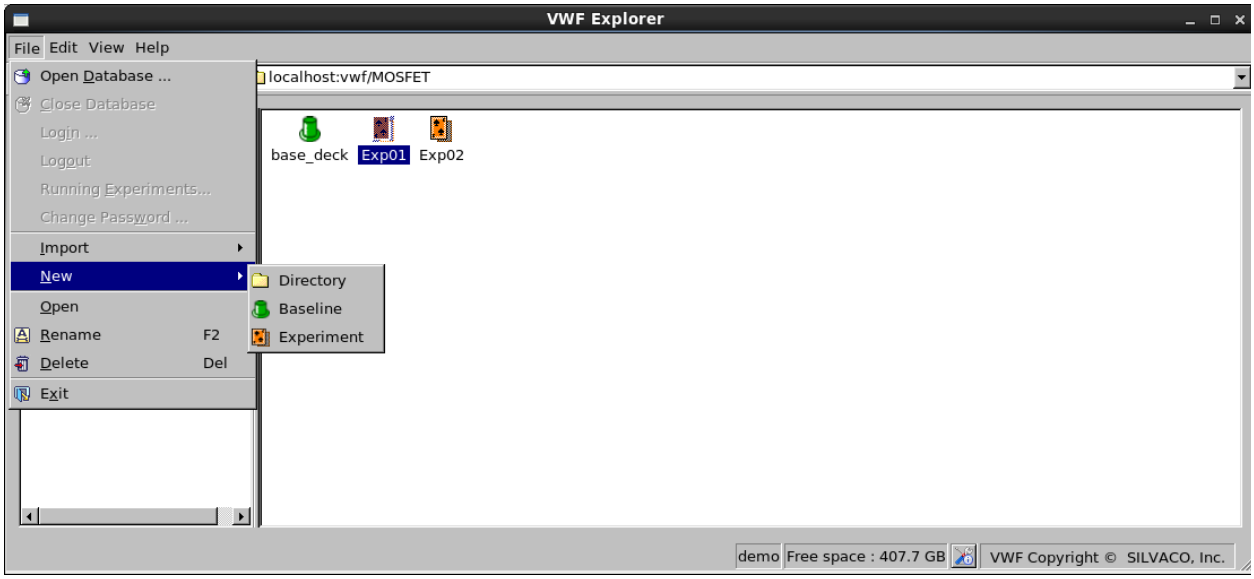


Figure 3-11 Main Window – File menu

Figure 3-12 shows the **Edit** menu. This allows you to cut/copy/paste experiments and also to enter the Preferences dialog.

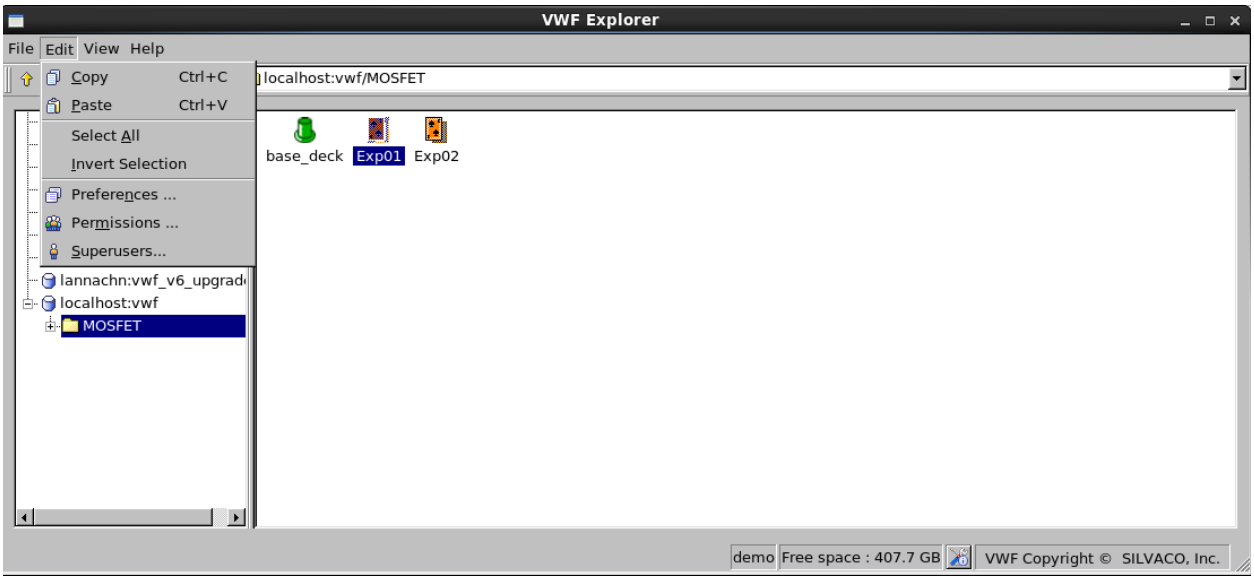


Figure 3-12 Main Window – Edit menu

Figure 3-13 shows the **View** menu. This allows you to apply filters and switch between the different available views of the Main Window.

Figure 3-13 Main Window – View menu

Figure 3-14 shows the List View of the main pane.

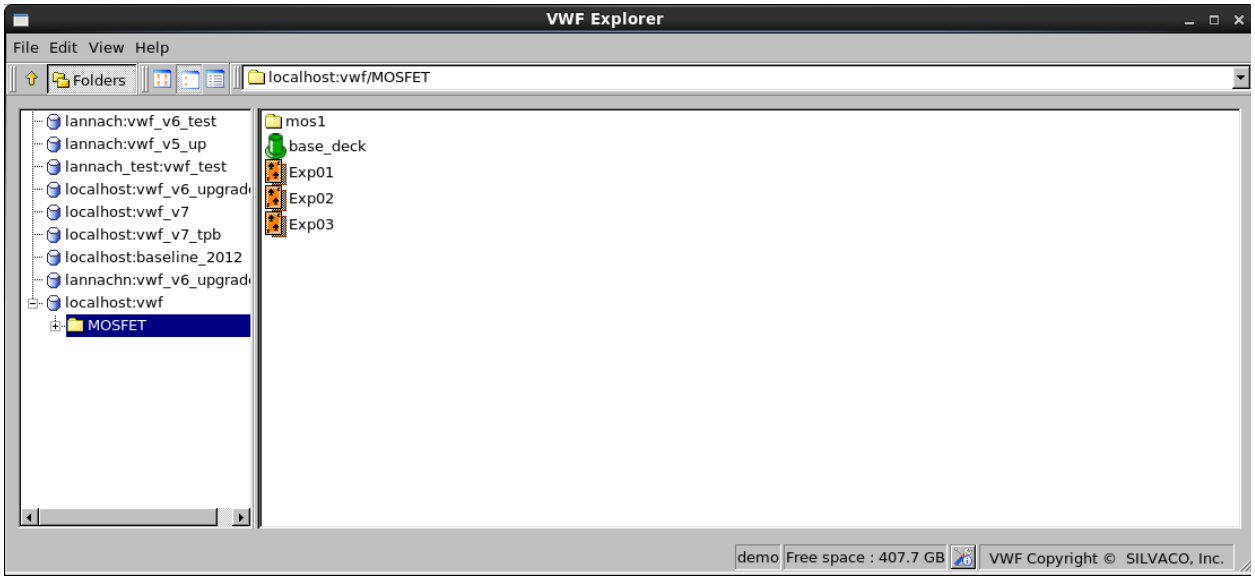


Figure 3-14 Main Window – List View

Figure 3-15 shows the main pane context menu, which appears upon a right-click in the main pane.

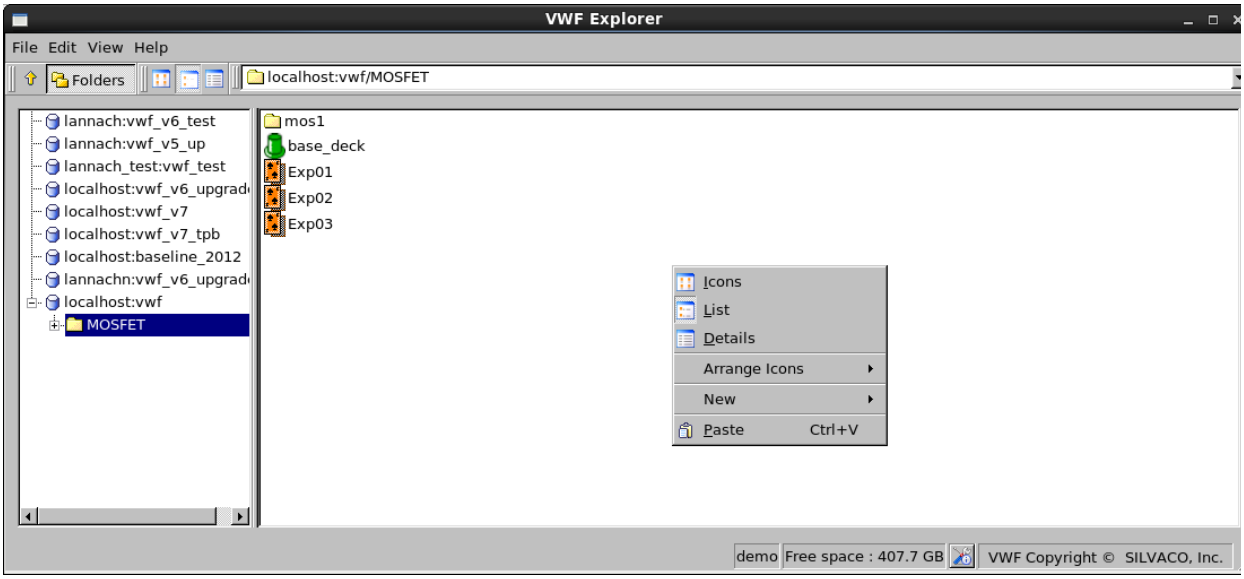


Figure 3-15 Main Window – Main Pane Context Menu

Figure 3-16 shows the Details View. Extra information like the date of last modification or the user who created the experiment is shown.

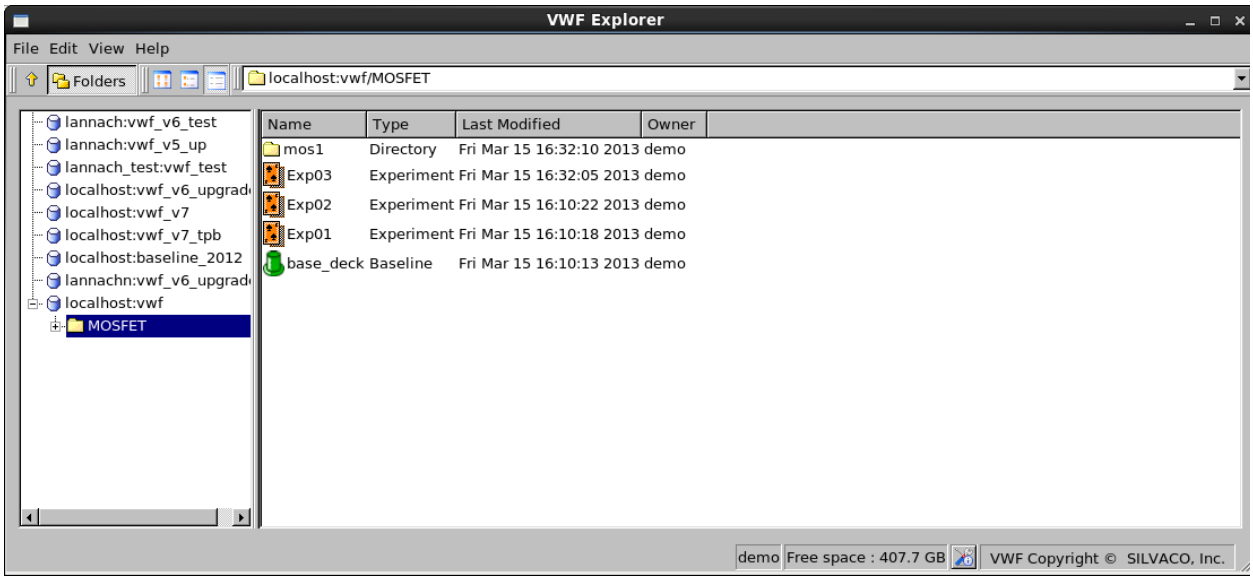


Figure 3-16 Main Window – Details View

Figure 3-17 shows the **Arrange Icons→By Name** entry of the main pane context menu.

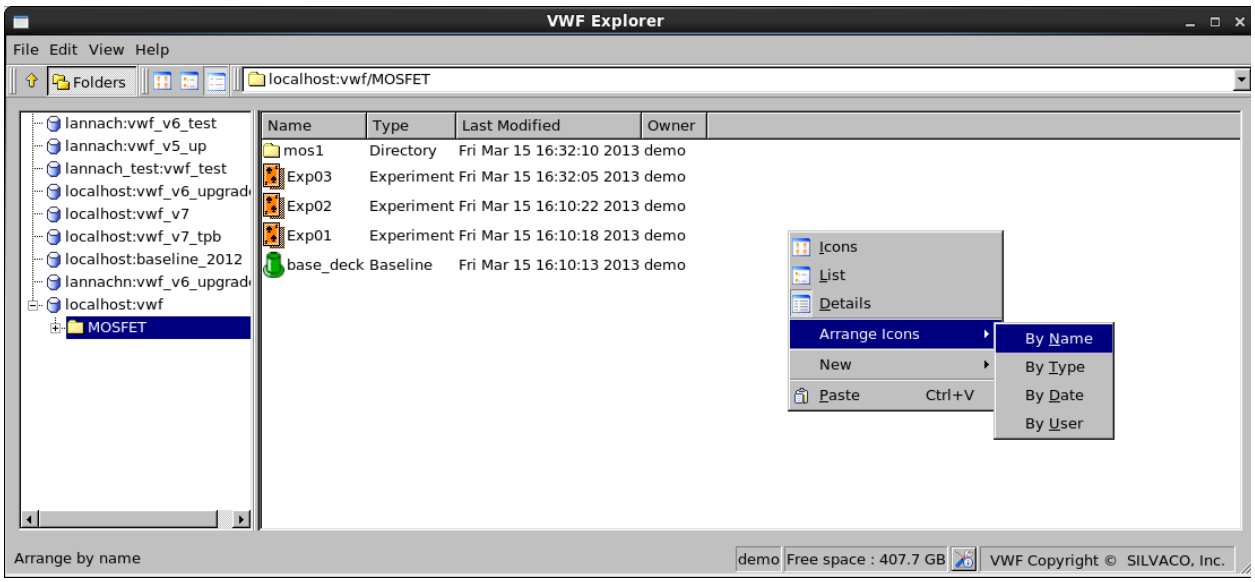


Figure 3-17 Main Window – Arrange Icons By Name entry

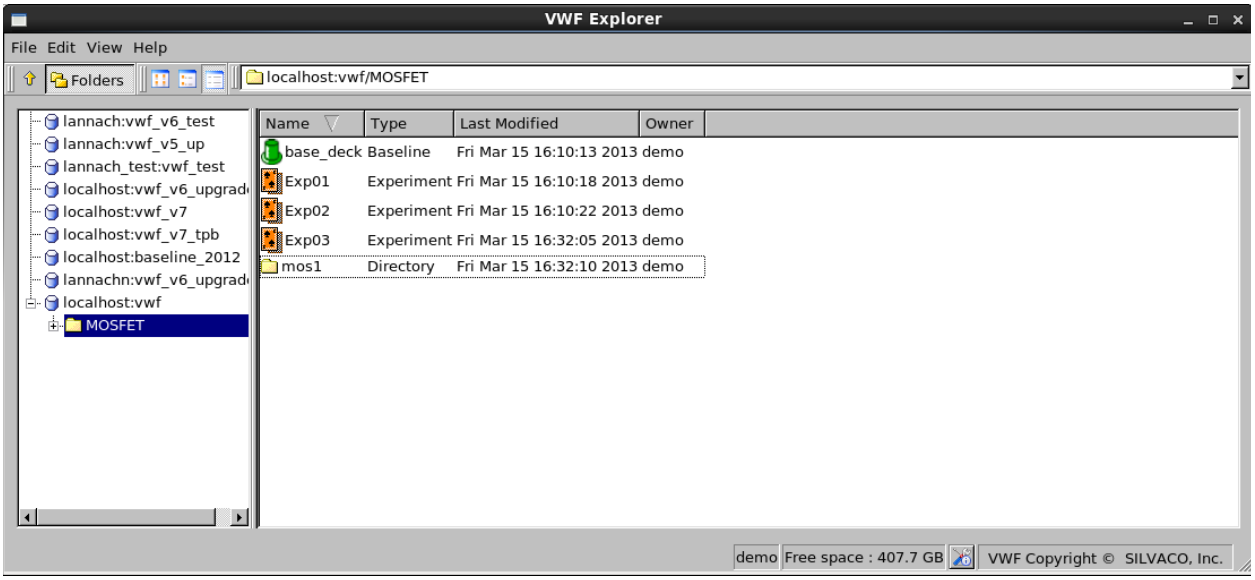


Figure 3-18 Main Window – Icons Arranged By Name

Figure 3-19 shows the menu entry to create a new experiment. To create new experiments, right click into main pane and select **New Experiment**.

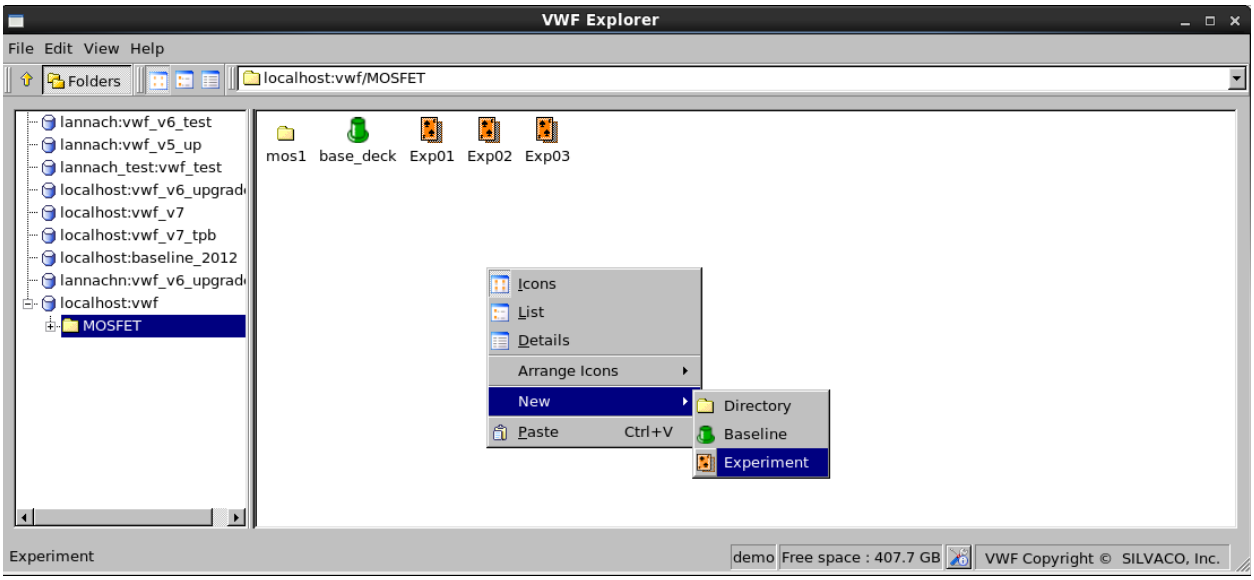


Figure 3-19 Main Window – New Experiment Menu Entry

Figure 3-20 shows the help menu entry. Selecting this menu entry will open the VWF manual.

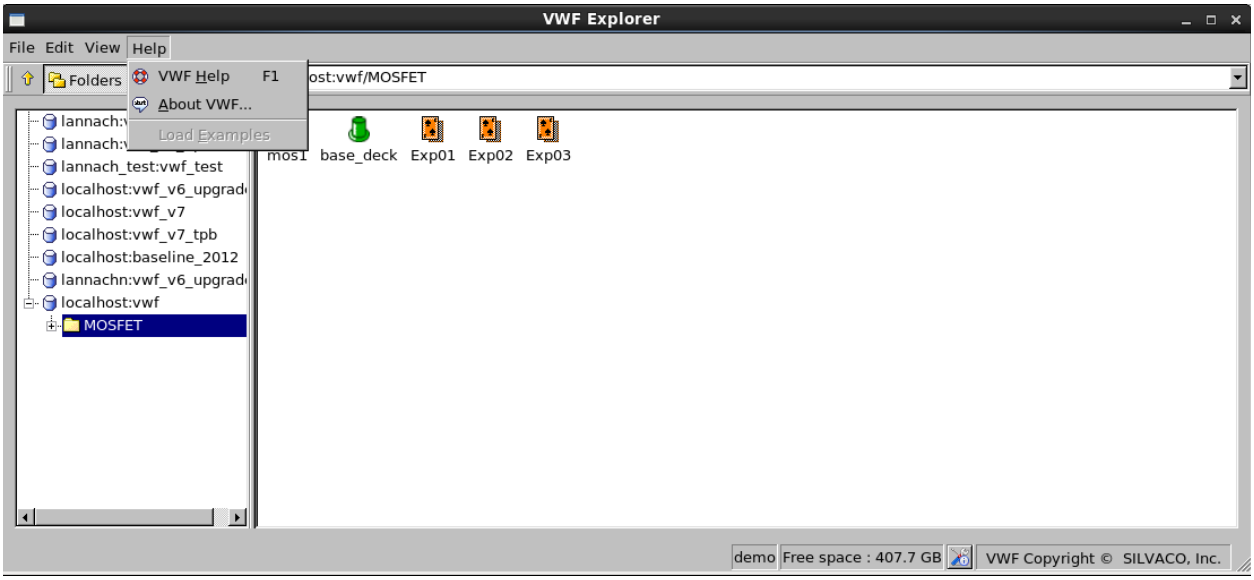


Figure 3-20 Main Window – VWF Help Menu Entry

The explorer allows you to move directories from one location to another. To do so, you have to select the directories to move. This is shown in Figure 3-21. You can select several directories for movement by holding down the Ctrl key and left-clicking the directories to move. If you select multiple directories, then the selected directories are rendered in red.

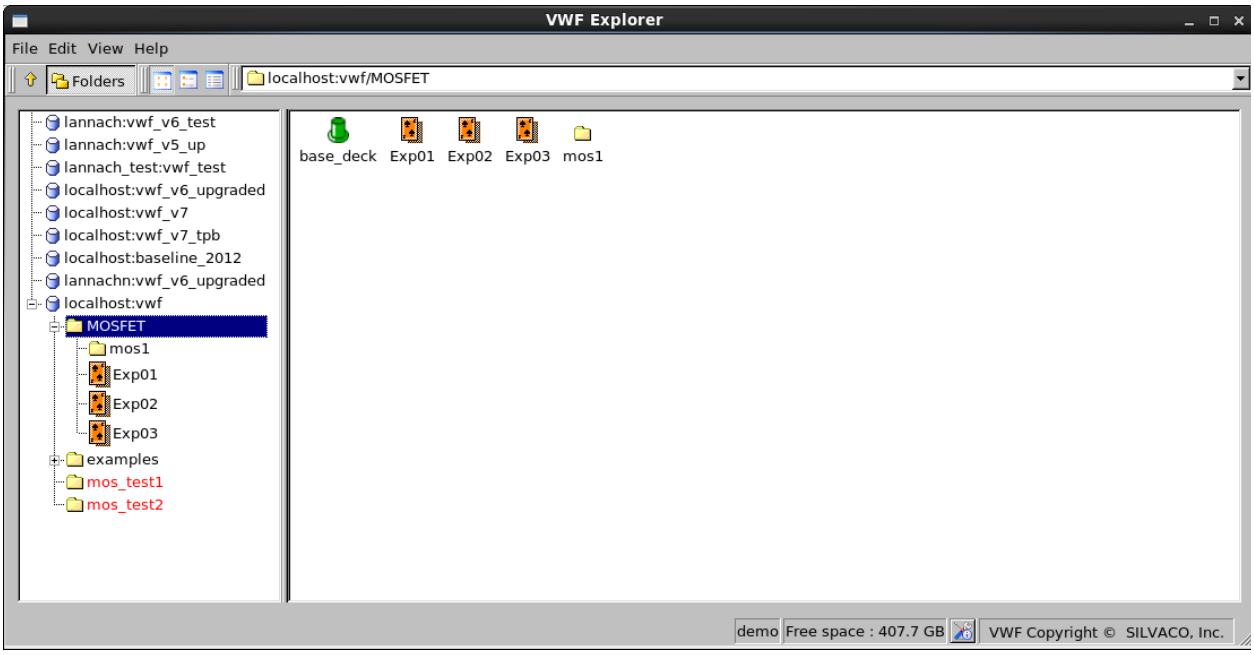


Figure 3-21 Selected Directories for Move

To initiate the move operation, press and hold down the left mouse button and drag the selection to the new location. Once you release the mouse button over the new location, the dialog shown in Figure 3-22 will open asking you to confirm the operation. If you select **OK**, then the move is started otherwise it is canceled.

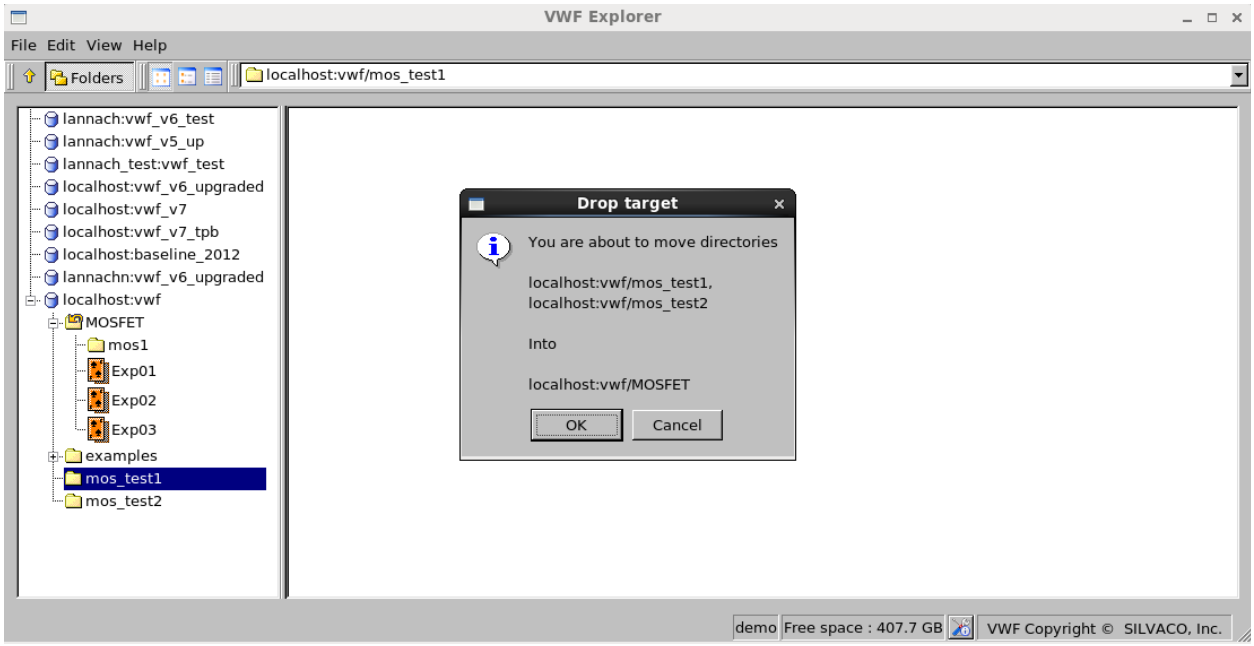


Figure 3-22 Dialog to Confirm Move Operation

Figure 3-23 shows how the directory tree has changed after the move operation was finished. In this example, directories named `nmos_test1` and `nmos_test2` were moved from the `root` directory to the directory called `MOSFET`.

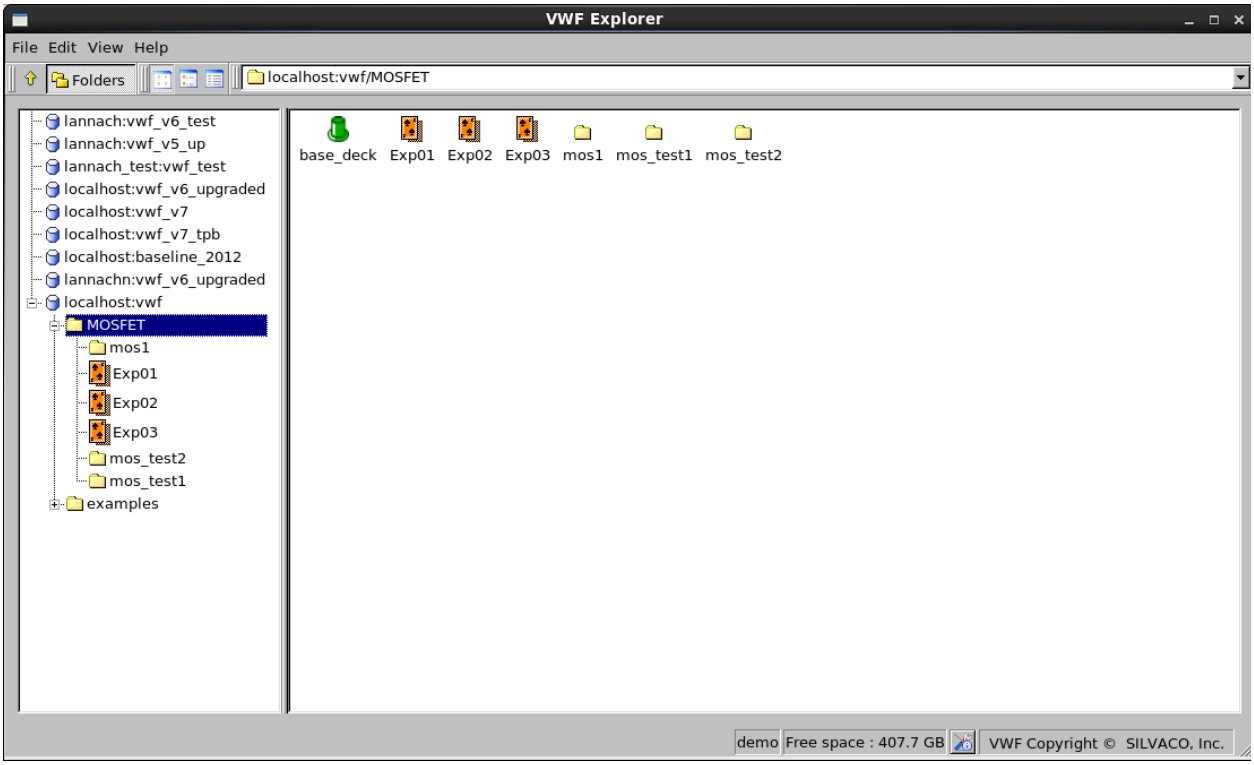


Figure 3-23 Resulting Directory Tree after Move Operation

3.3.2 Creating a New Experiment

In order to create a new experiment, you will first need a directory to hold the experiment. Experiments cannot be stored in the root directory. Once a directory is created, you will then need to create a baseline. Finally, based on this baseline, you can then create an arbitrary number of experiments. When experiments are created, the baseline deck is taken as a starting point. Both the baseline deck as well as the deck in the experiment can be edited independently from each other. Editing the base deck does not influence the deck of an experiment and vice versa. Editing the base deck has the effect that all newly created experiments will be created with the changed baseline.

Figure 3-24 shows the dialog to create a new baseline deck. You can choose to either import a deck from the filesystem, from CVS, or from DeckBuild. Please refer to Chapter 5 “Tutorial” for a more detailed description of how to import a deck using DeckBuild.

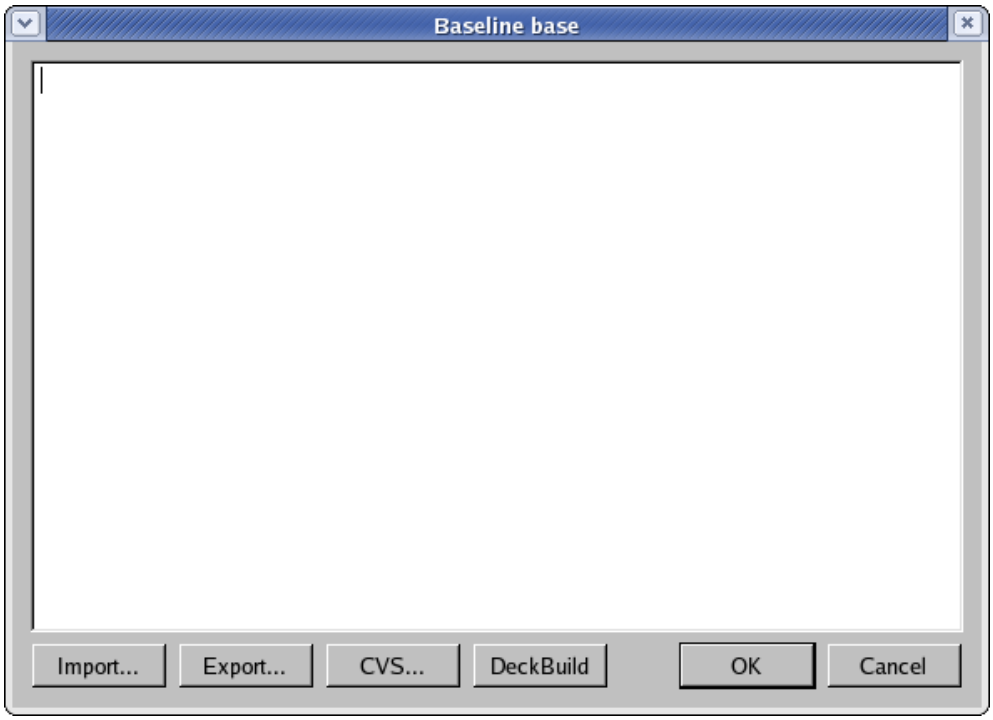


Figure 3-24 Dialog to Create A Baseline Deck

Figure 3-25 depicts how a CVS repository can be accessed. You need to enter host, repository location, and valid user credentials.

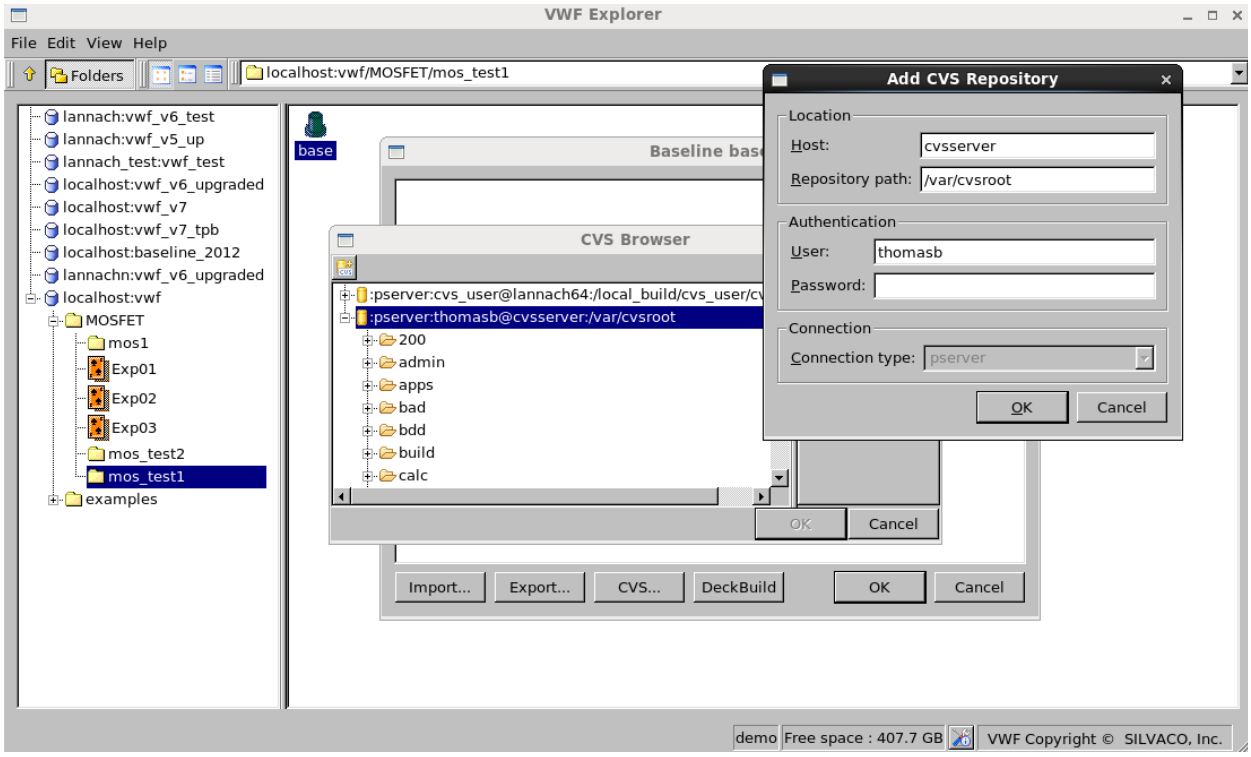


Figure 3-25 CVS Repository Information

Figure 3-26 shows a populated tree after a successful browse operation. The available content of the CVS repository is shown. Here, some Athena and Victory examples are shown. In the right-hand side of Figure 3-26 two files, which have been checked out are shown. The left pane shows the file `anstex01.in` from the directory `decks/athena/athena_stress.in`. The right pane shows the file `vpex01.in` from the directory `decks/victoryp/vpex01.in`. One of the checked out files can be chosen to become the baseline.

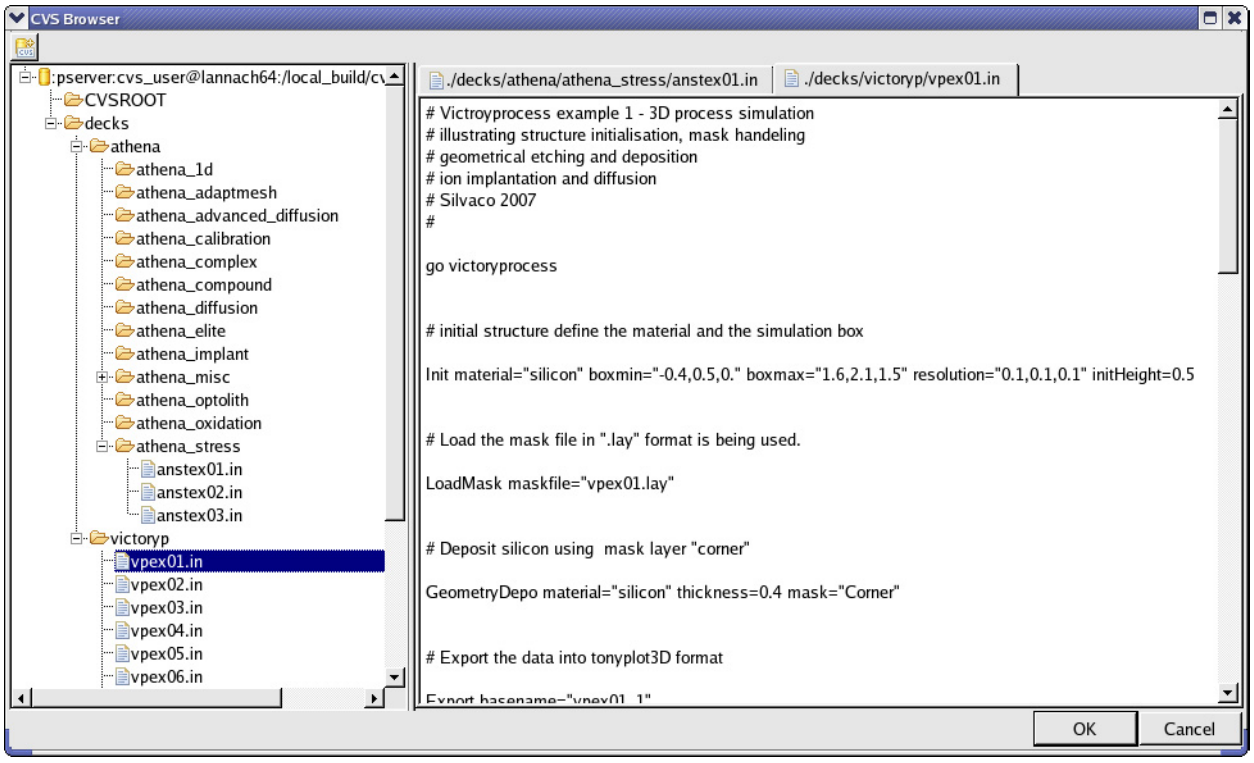


Figure 3-26 Browse View of CVS Repository. Two files have been checked out.

3.3.3 Experiment Editor

Figure 3-27 shows the Experiment Editor. Please refer to Figure 6-3 for the optimization experiment type. This window appears whenever you create a new experiment or open an existing one. The editor is used to collect all data necessary to execute an experiment. The window is composed of several tabs. These are **Description**, **Resources**, **Deck**, **Tree**, **Worksheet**, **Jobs**, and **SplitPlot Worksheet**. To open a particular tab, click on the according label. Figure 3-27 shows the **Description** tab open. It displays the name of the opened experiment (`vwfex02`). The shown example is one of the prepared simulation examples that are shipped with VWF, which is also available from the Silvaco website.

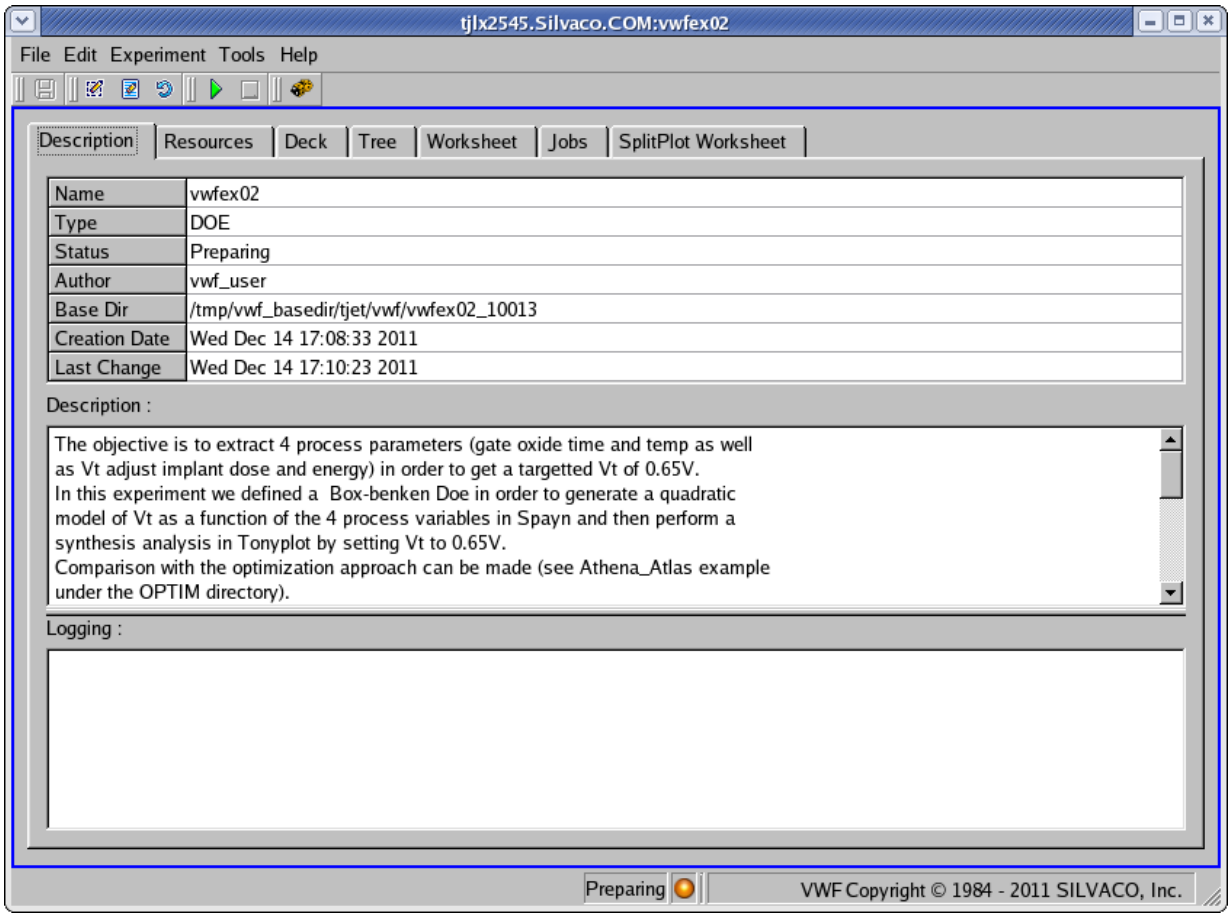

tjlx2545.Silvaco.COM:vwfex02
File Edit Experiment Tools Help
Description
Resources
Deck
Tree
Worksheet
Jobs
SplitPlot Worksheet
Name
vwfex02
Type
DOE
Status
Preparing
Author
vwf_user
Base Dir
/tmp/vwf_basedir/tjet/vwf/vwfex02_10013
Creation Date
Wed Dec 14 17:08:33 2011
Last Change
Wed Dec 14 17:10:23 2011
Description :
The objective is to extract 4 process parameters (gate oxide time and temp as well
as Vt adjust implant dose and energy) in order to get a targetted Vt of 0.65V.
In this experiment we defined a Box-benken Doe in order to generate a quadratic
model of Vt as a function of the 4 process variables in Spayn and then perform a
synthesis analysis in Tonyplot by setting Vt to 0.65V.
Comparison with the optimization approach can be made (see Athena_Atlas example
under the OPTIM directory).
Logging :
Preparing
VWF Copyright © 1984 - 2011 SILVACO, Inc.

Figure 3-27 Experiment Editor – Description tab

The base directory of an experiment is the top-level directory, which is used for carrying out simulations with any of the Silvaco simulation tools. A template for this base directory has been selected during the installation procedure of VWF. When experiments are created, this template is taken as the prefix for the base directory for the experiment.

Note: In filemode, simulations are run in a sub-directory of the directory where the experiment file is stored.

Figure 3-28 depicts how you can manipulate the resources of the VWF experiment. A resource is a file that is needed when you execute an experiment (run the simulations of the experiment). Essentially, all files that are mentioned in an input deck are resources. Typical usage scenarios for resources are mask files, or initialization files for simulators. There are two possible ways of dealing with resources. They can either be linked from the file system or they can be stored in the database. Figure 3-28 depicts both variants. The file `a.lib` is stored in the database. During the runtime of an experiment, database stored files are copied into the base directory of the experiment (into a sub-directory called `resources`) and links to those files are created from every (sub)directory where a simulation is carried out. In contrast, the resource called `ref.dat` is a linked resource, which resides in the directory `/tmp/VWF/Resources`. No copy of that file is created, it will directly be linked to from the simulation sub-directories of the experiment. It is therefore essential for a successful completion of the simulation that linked resource files are available at the time of experiment execution. The experiment depends on these external files.

The advantage of database stored resources is that the files are copied (rather than referenced) on import and do not need to be kept in the original location beyond the import operation. One of the trade offs between linking and copying is the amount of used disk space. This can be important if mask files will be reused among various experiments or users. Another aspect to take into account is that a change in a linked mask is reflected in every experiment, which uses (links to) that particular mask. It should thus be decided from case to case whether to use external resources.

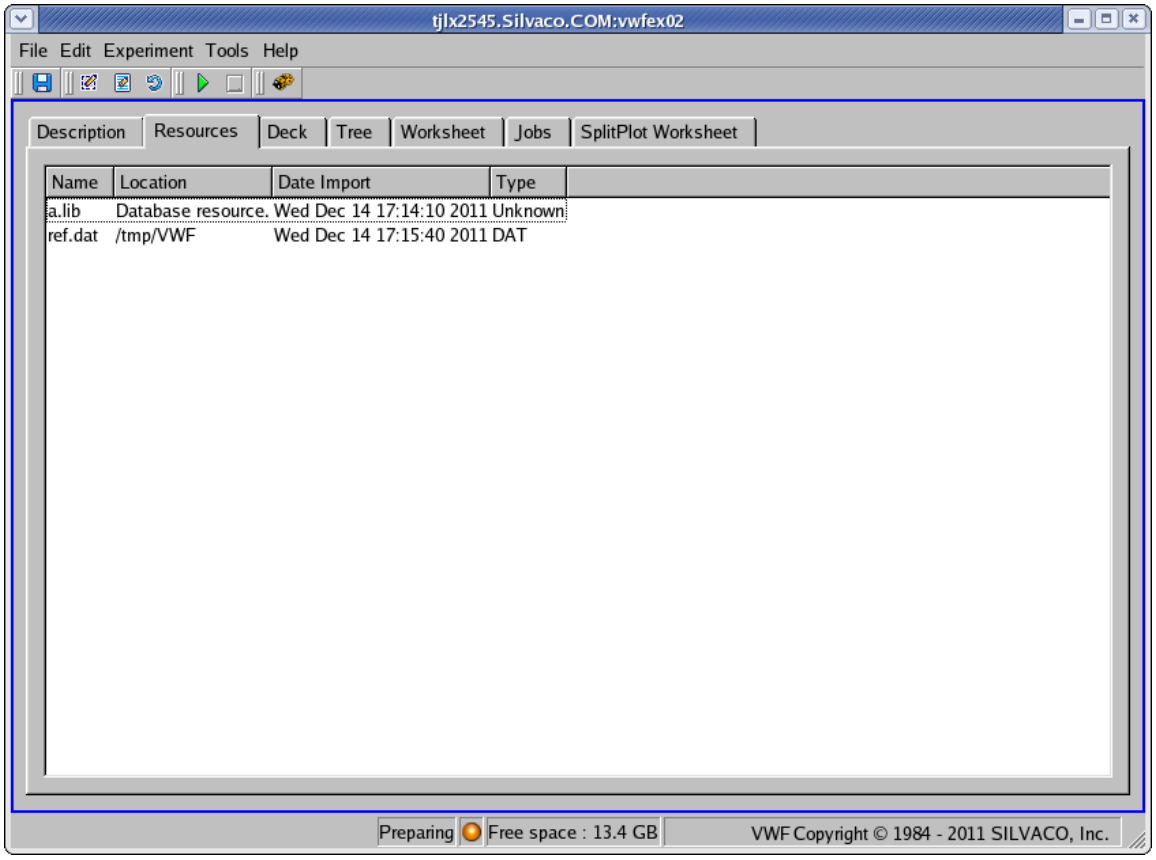


Figure 3-28 Experiment Editor – Resources tab

Figure 3-29 shows the VWF Deck Editor. This editor allows you to nominate parameters as split variables. To nominate a parameter right-click on any deck line (as shown in Figure 3-30) to pop up a list of available parameters of that deck line. Select one of the shown parameters. By selecting a parameter twice, it is denominated again. A syntax highlighting scheme is used in the deck, so that a selected parameter can easily be identified in the deck. A selected parameter is drawn in red. As additional information, the bottom part of this tab shows a list of all nominated parameters. The syntax highlighting scheme will also draw all commented deck lines in green.

In this example, the screen shot shows two parameters in the bottom part (`time` and `temp`) and four (different) parameters in the deck pane (called `time`, `temp`, `dose`, and `energy`). The bottom pane of the **Deck** tab also shows block, type, and initial value of the parameter. The notion of a block is used to group parameters of a single deck line. The block is also visible in the tree tab and will be shown in another screen-shot.

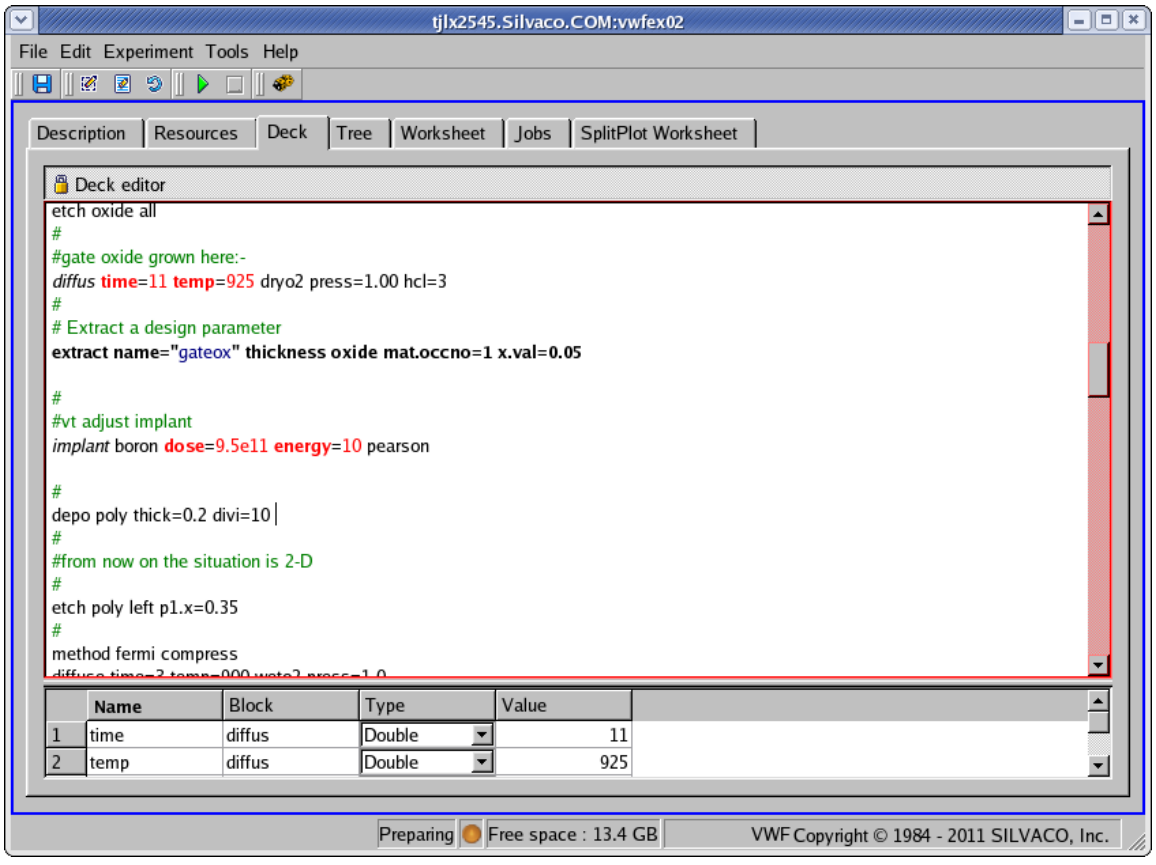


Figure 3-29 Experiment Editor – Deck tab

Figure 3-20 shows the menu that opens when you right-click on a deck line. Here, two entries, `time` and `temp`, of the clicked `diffus` line are shown as the active parameter. Three parameters, `dryo2`, `press`, and `hcl` are available as further parameters on this line. Thereby, the menu entries correspond to the list of active parameters of that line as shown in Figure 3-29).

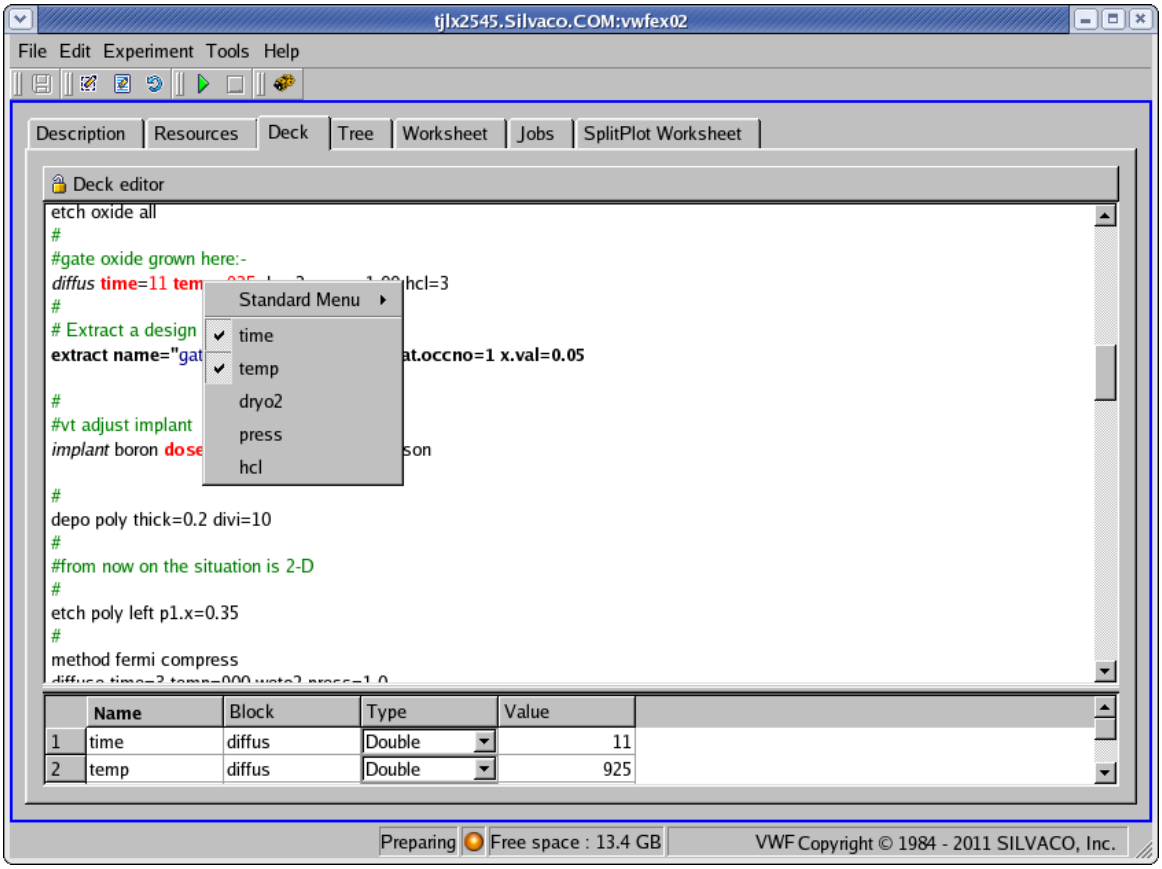


Figure 3-30 Experiment Editor – Split Parameter Definition

Right-clicking on any of the parameters in the lower pane of the deck editor reveals a context menu with two entries (Figure 3-31). **Locate** will position the cursor in the main deck pane and within the parameter. **Remove** will remove the parameter from the list of split parameters and the coloring will return to that of regular deck text. You can also select **Locate** by simply double-clicking on any of the parameter's **Value**, **Block**, or **Type** fields.

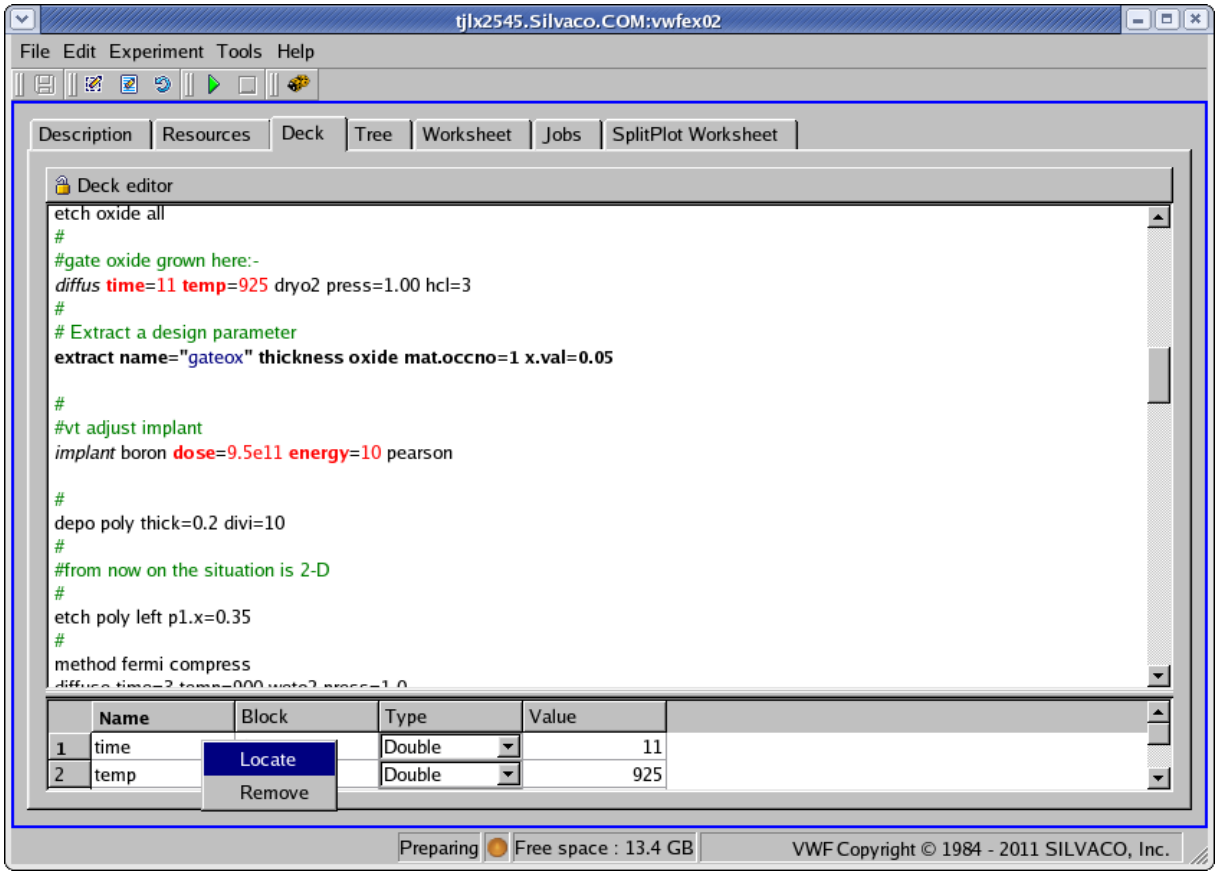


Figure 3-31 Experiment Editor – Split Parameter Context Menu

Note: Extract statements are recognized whenever a new deck is imported into the experiment or when a new extract statement is added by editing the deck in the deck tab .

You can use the Find Text dialog (Figure 3-32) to search for arbitrary text elements in the deck. To open the dialog, press Ctrl-F within the deck editor pane.

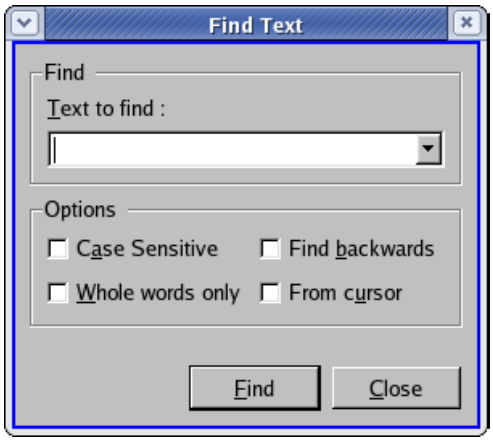


Figure 3-32 Find Text Dialog

Figure 3-33 shows the **Tree** tab. The **Tree** tab presents a view at the split tree. Parameters are grouped in blocks. The split tree results from the set of split parameters and the assigned split values. In the depicted example, there are two parameter blocks. One block is called `diffus`. It consists of parameters `time` and `temp`. The other block is called `implant`. It consists of parameters `dose` and `energy`. Adding or removing a parameter in the deck pane (Figures 3-29 and 3-30) will directly influence the split tree. The right-hand side of the depicted tree tab shows a legend with block and parameter names. At the top left, there is a legend explaining simulation job status and displays a brief job statistic. This legend also shows how the color of nodes corresponds to the state of a given job. Here, no job has been queued into the job farming system so far. You can move this legend anywhere in the pane.

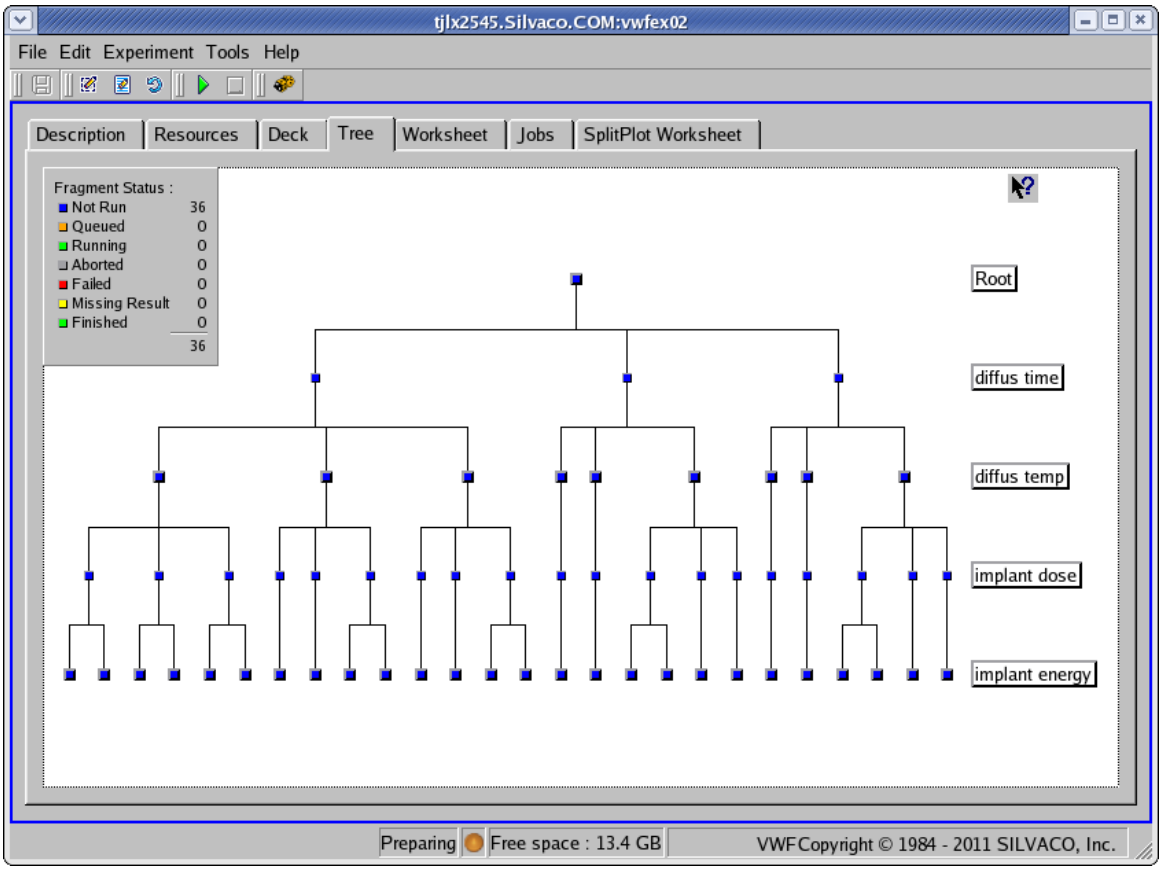


Figure 3-33 Experiment Editor – Tree tab

Apart from the coloring scheme, the nodes are also drawn in different shapes depending on whether several parameters occur at a single deck line. For such parameters, all but the last parameter a drawn thinner. In Figure 3-33, the split parameter named `implant dose` is the first of two parameters on a single deck line. The split parameter named `implant energy` is the second and last parameter on this deck line. This is indicated by drawing the node a little fatter. Only the fat nodes have results and result files available for inspection.

The pane also shows an icon with an arrow and a question mark. You can click on this icon and then click on any component in the tree pane to get useful help information displayed.

You can zoom into large DOE trees, which don't fit into the tree pane as a whole. To do so, use the SHIFT key of your keyboard together with the left mouse button to draw a rectangle. Once the mouse button is released, the view of the tree pane is updated to only contain the nodes you selected when drawing the rectangle. Figure 3-34 depicts a part of the tree from Figure 3-33. You can also see that a little icon was added showing a “-” sign. Clicking on this icon will zoom out. Zooming is organized in zoom levels. Every time you start a zoom on a previously zoomed view another level is created. The first zoom from the initial tree view creates level 1, the second zoom creates level 2, and so forth. By clicking on the “-” sign, you are effectively going back one zoom level at a time.

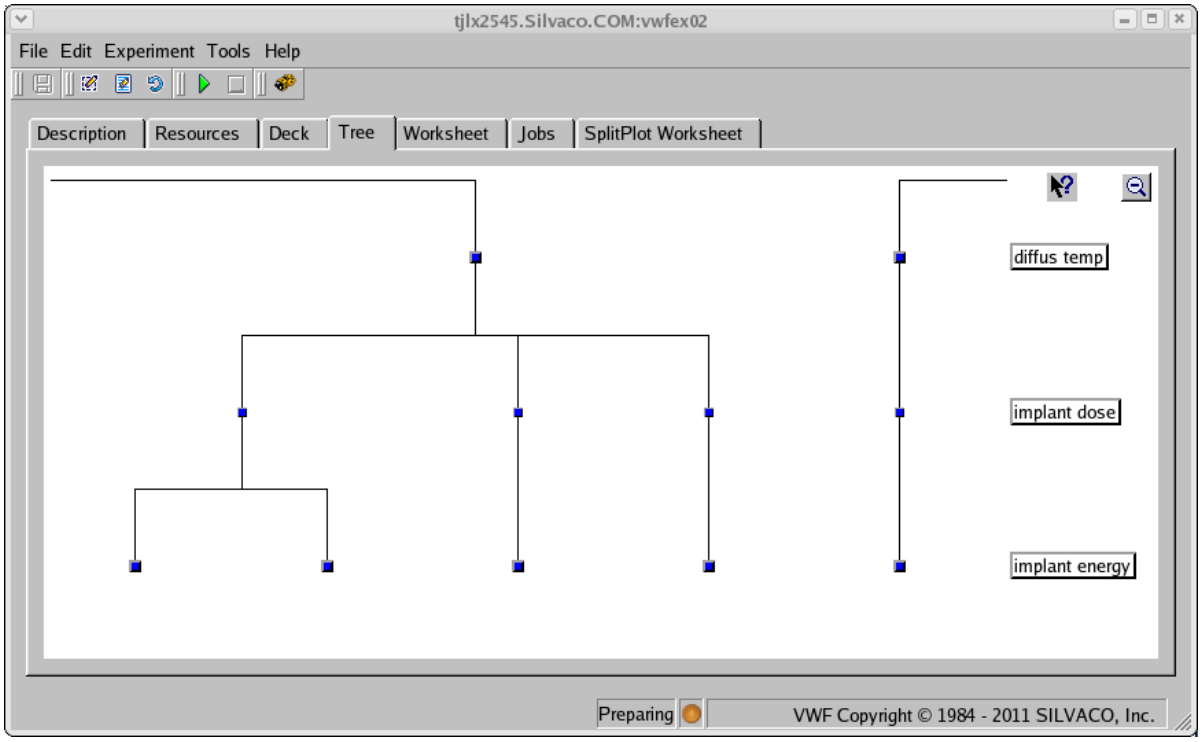


Figure 3-34 View at Zoomed in Tree

You can decide to hide parts of the tree by folding away a sub-tree. The folding functionality is invoked by holding down the SHIFT key and left-clicking on the node you want to fold. The function is realized as a toggle switch so that a once folded tree can be unfolded again by SHIFT left-clicking on the very same node again.

Figure 3-35 displays the tree from Figure 3-33 with the two outer most nodes of the `diffus time` parameter folded away. This is also visually indicated by a small triangle shape right below the node.

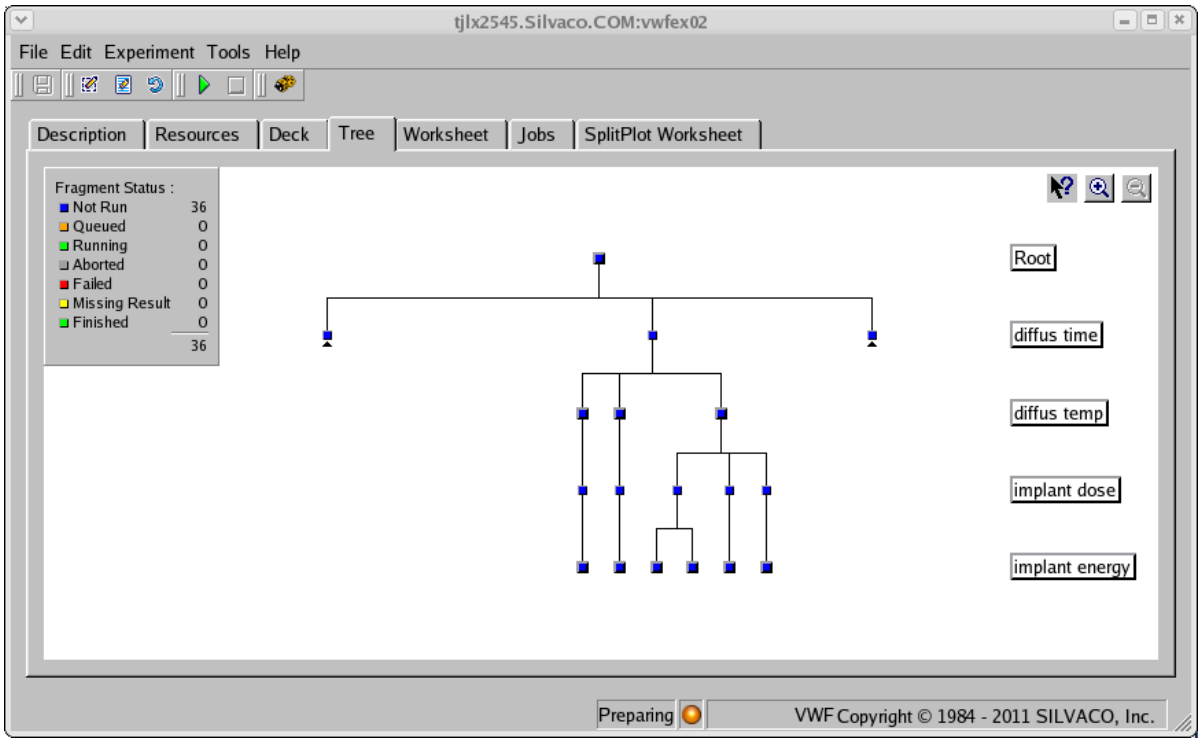


Figure 3-35 Tree with folded Sub-Trees

For every node, a detailed job status information can be displayed. To display this information, open the Node Information dialog (Figure 3-36) by right-clicking at any node. This dialog displays name and status of the node and any simulation results, which might become available after a completed simulation. Additionally, the runtime output of a simulation is shown (bottom). There are two tabs corresponding to the standard output and the standard error of a simulation job respectively. In case you are experiencing troubles with simulations, it is advisable to check both output tabs. Click **OK** to close the dialog. Selecting a different node while the dialog is still active will update the shown information with the details of the newly selected node. You can resize the panes by clicking and dragging on the edge between any two panes.

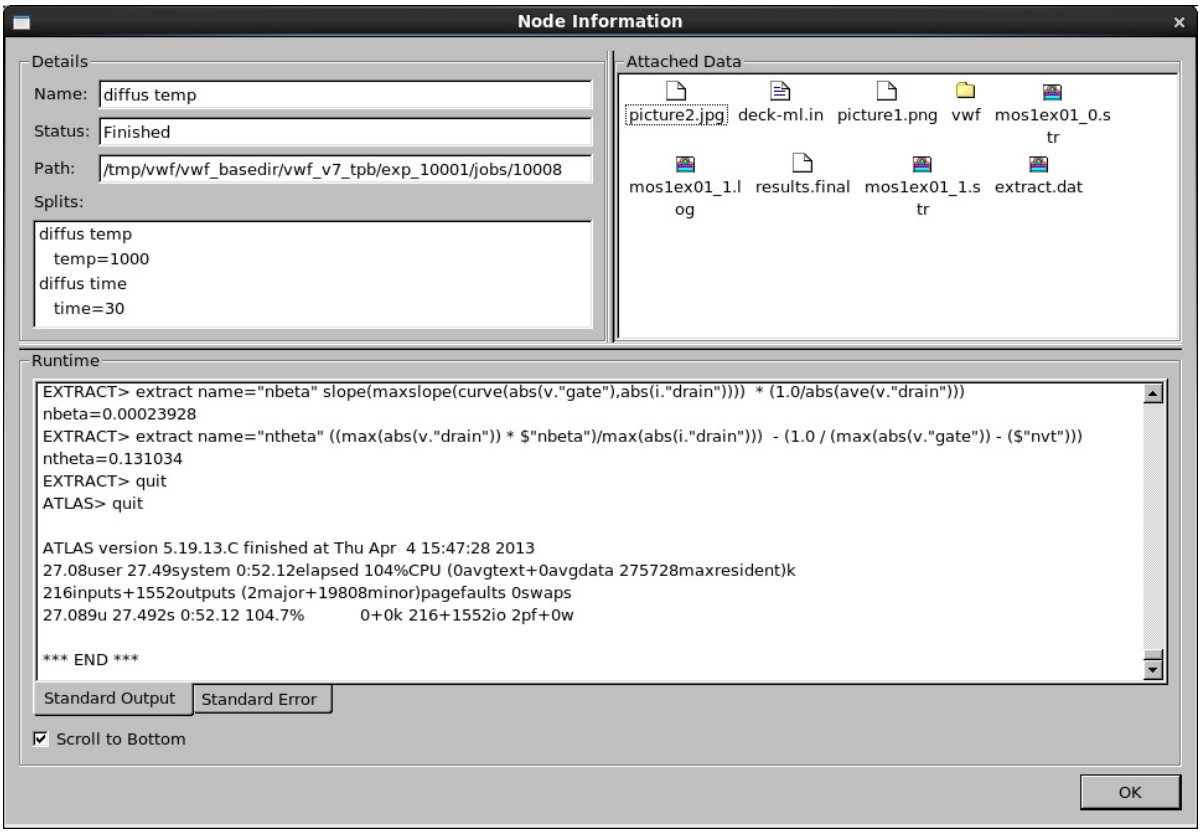


Figure 3-36 Node Information dialog

The node information dialog also allows you to open any file that is shown in the Attached Data pane. Some of the file types have pre-defined tools associated. These are well known file formats, like 2D/3D structure files (`.str`) or `.log` files, as created by Atlas. You can see that a TonyPlot icon is shown for the mentioned file types. Other files like the simulation deck of the node (`deck-ml.in`) are associated with a text editor. The icon shown in the pane indicates that this file is opened using a text file when double-clicked. Finally, there are also files for which no tool is pre-defined. In Figure 3-36, there are two files called `picture1.png` and `picture2.png`. The icon indicates that no application has been associated with these file types. Double-clicking on such an icon will produce the error message shown in Figure 3-37.

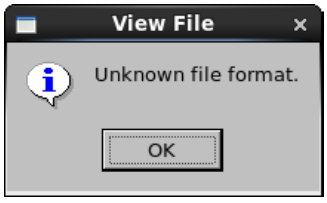


Figure 3-37 Unknown File Type

You can associate a command with a file type by right-clicking on the file and selecting **Open With** from the menu. A dialog as shown in Figure 3-38 will open. The dialog allows to select among one of several know types as well as to define a custom type. Here, the utility display is assigned with files ending in .jpg. If you check the **Always use this program to open these files**, then the association is permanently kept in the preferences under the point **Registered Filetypes**. If you do not check this box, then the association is lost when you restart VWF. By clicking Ok, the file `picture2.jpg` is opened by running the command:

```
display /tmp/vwf/vwf_basedir/vwf_v7_tpb/exp_10001/jobs/10008 picture2.jpg
```

Please note the used path as indicated in Figure 3-38.

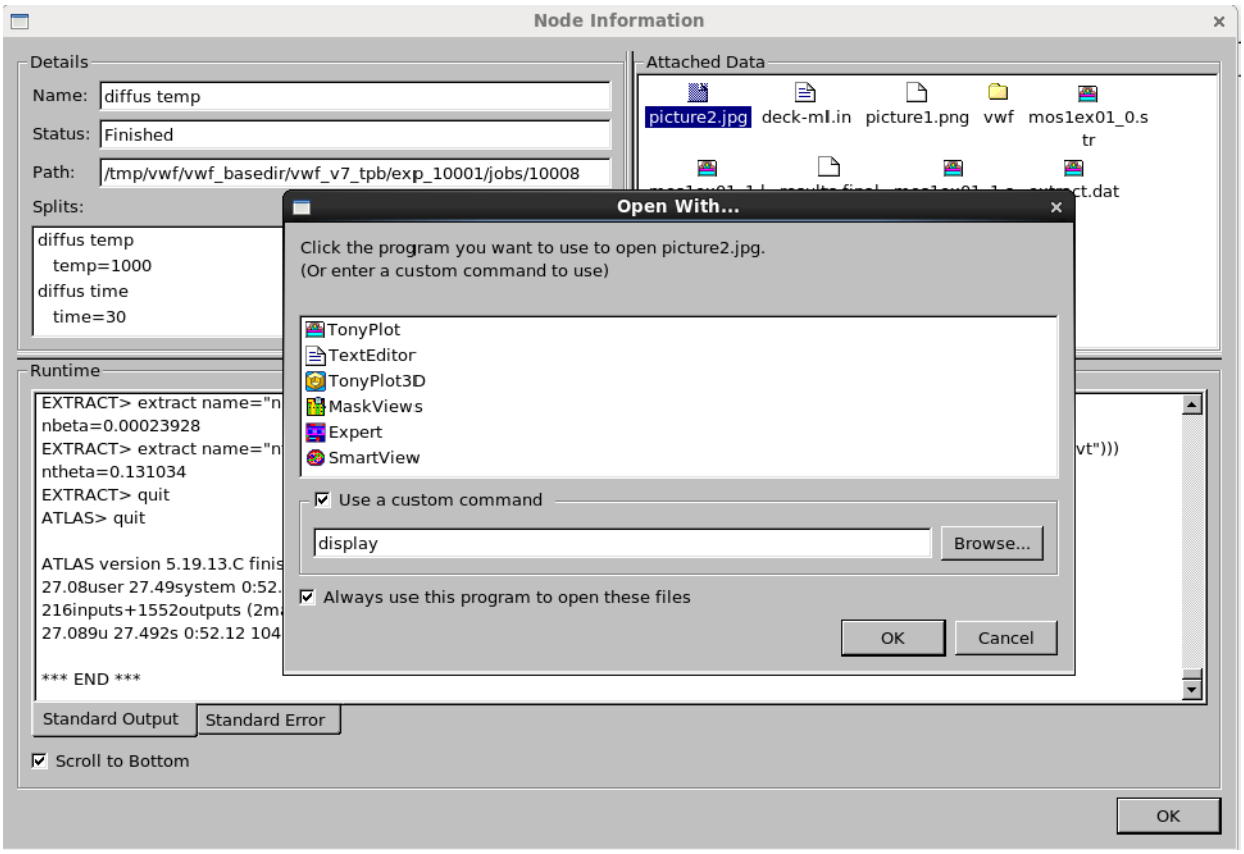


Figure 3-38 Associating an application with a particular file type

If the file name needs to be in the middle of the command, you can use a placeholder as shown in Figure 3-39. This will then result in the following command being executed upon clicking **OK**.

```
display  /tmp/vwf/vwf_basedir/vwf_v7_tpb/exp_10001/jobs/10008/picture2.jpg
-antialias
```

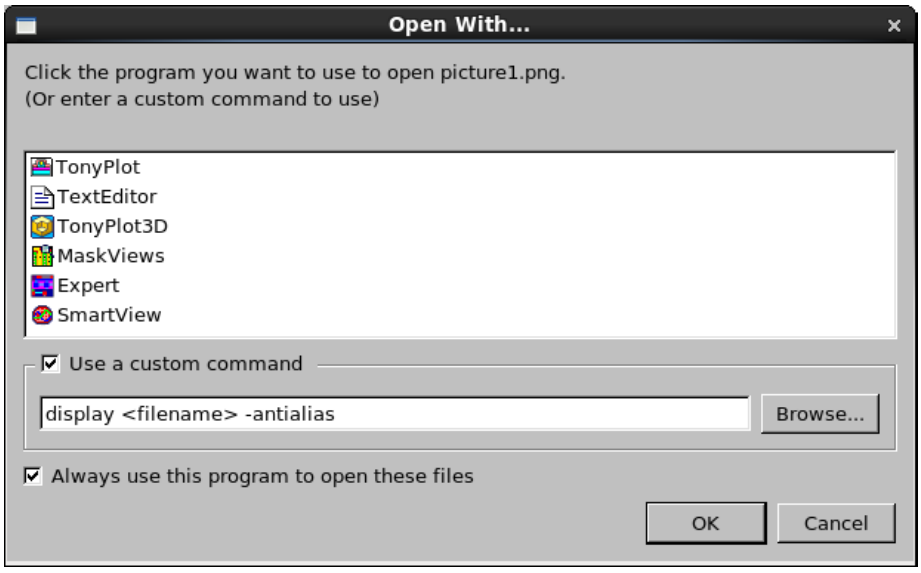
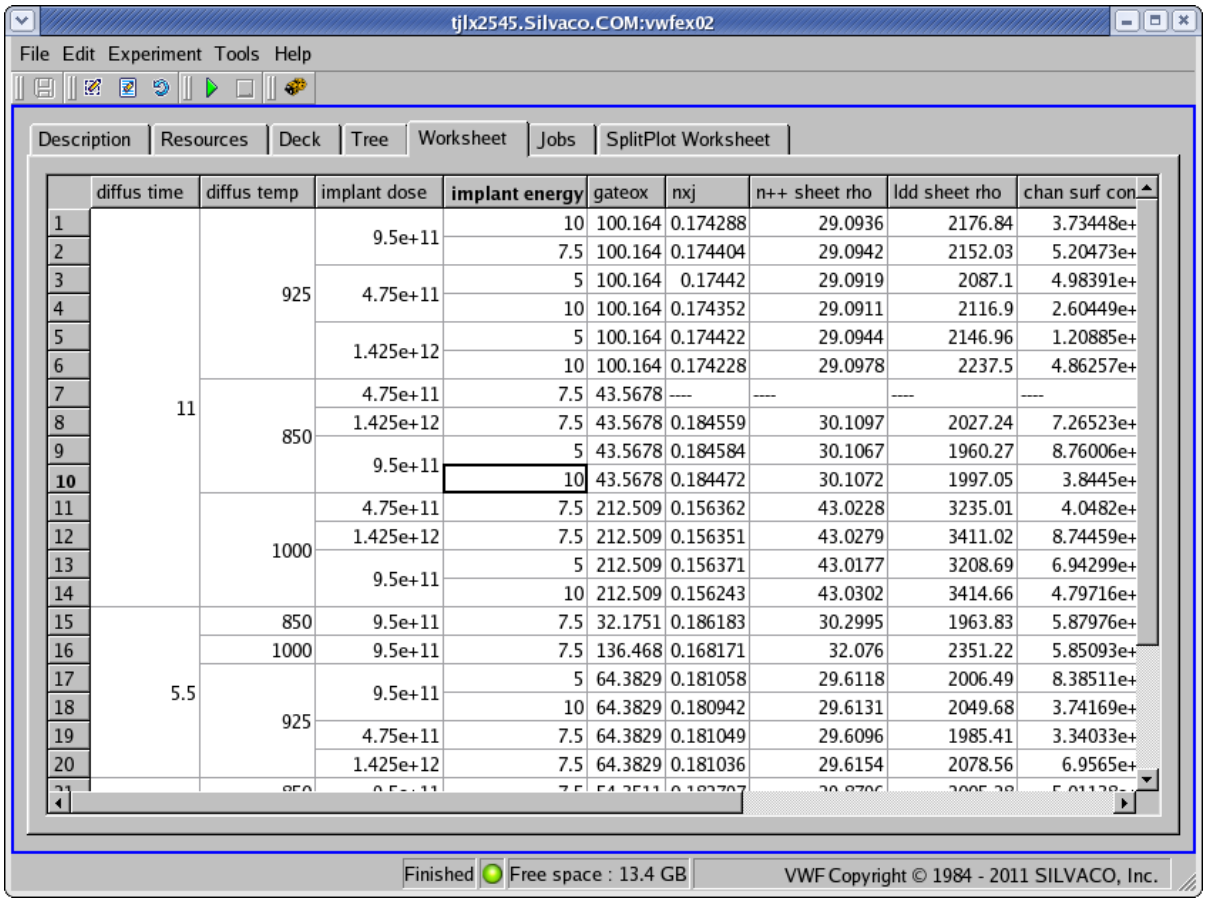


Figure 3-39 Using a Placeholder for the File Name

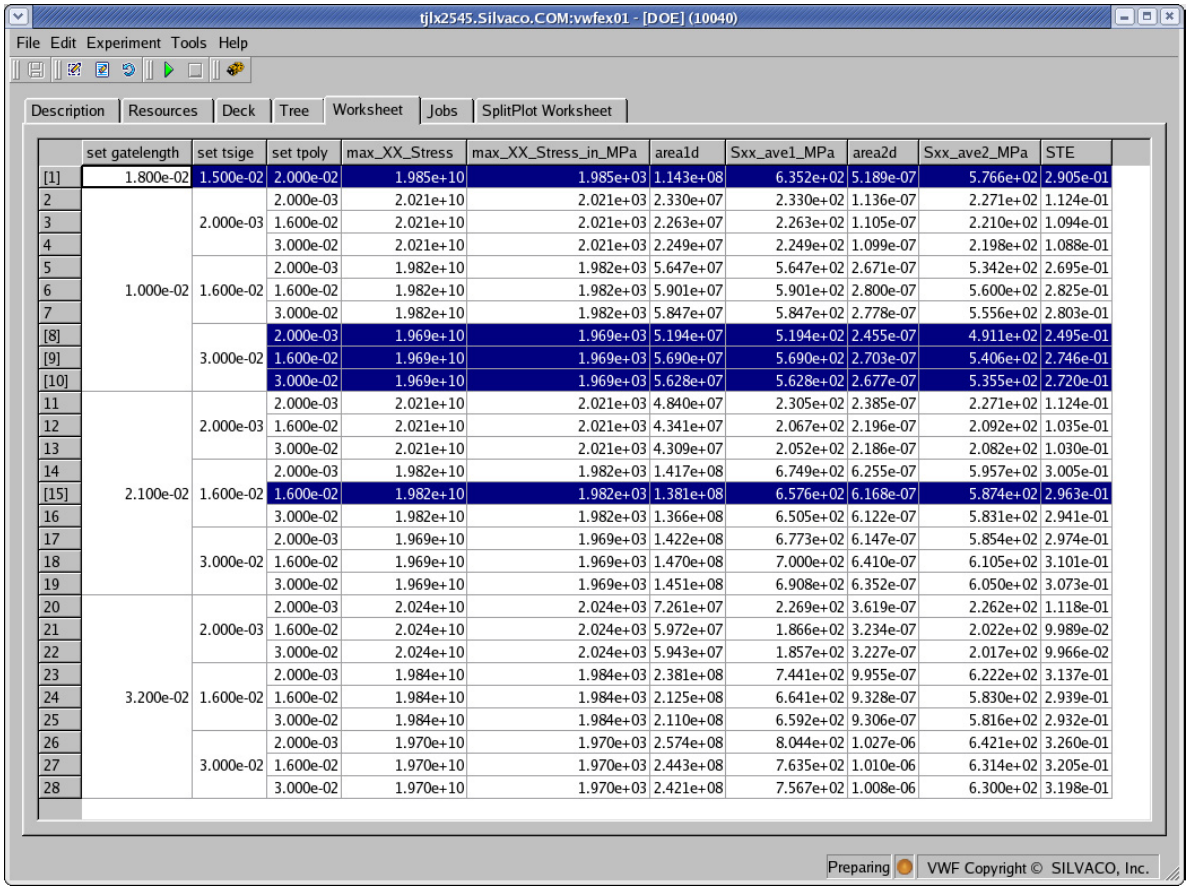
Figure 3-40 shows the **Worksheet** tab. The worksheet serves two purposes. First, it is used to assign split point values to split parameters. Second, it contains all parameters extracted during simulation.


tjlx2545.Silvaco.COM:vwfex02
File Edit Experiment Tools Help
Description Resources Deck Tree Worksheet Jobs SplitPlot Worksheet
Finished Free space : 13.4 GB VWF Copyright © 1984 - 2011 SILVACO, Inc.

	diffus time	diffus temp	implant dose	implant energy	gateox	nxj	n++ sheet rho	ldd sheet rho	chan surf con
1	11	925	9.5e+11	10	100.164	0.174288	29.0936	2176.84	3.73448e+
2				7.5	100.164	0.174404	29.0942	2152.03	5.20473e+
3			4.75e+11	5	100.164	0.17442	29.0919	2087.1	4.98391e+
4				10	100.164	0.174352	29.0911	2116.9	2.60449e+
5			1.425e+12	5	100.164	0.174422	29.0944	2146.96	1.20885e+
6				10	100.164	0.174228	29.0978	2237.5	4.86257e+
7		850	4.75e+11	7.5	43.5678	----	----	----	----
8			1.425e+12	7.5	43.5678	0.184559	30.1097	2027.24	7.26523e+
9			9.5e+11	5	43.5678	0.184584	30.1067	1960.27	8.76006e+
10				10	43.5678	0.184472	30.1072	1997.05	3.8445e+
11		1000	4.75e+11	7.5	212.509	0.156362	43.0228	3235.01	4.0482e+
12			1.425e+12	7.5	212.509	0.156351	43.0279	3411.02	8.74459e+
13			9.5e+11	5	212.509	0.156371	43.0177	3208.69	6.94299e+
14				10	212.509	0.156243	43.0302	3414.66	4.79716e+
15	5.5	850	9.5e+11	7.5	32.1751	0.186183	30.2995	1963.83	5.87976e+
16		1000	9.5e+11	7.5	136.468	0.168171	32.076	2351.22	5.85093e+
17		925	9.5e+11	5	64.3829	0.181058	29.6118	2006.49	8.38511e+
18				10	64.3829	0.180942	29.6131	2049.68	3.74169e+
19			4.75e+11	7.5	64.3829	0.181049	29.6096	1985.41	3.34033e+
20			1.425e+12	7.5	64.3829	0.181036	29.6154	2078.56	6.9565e+

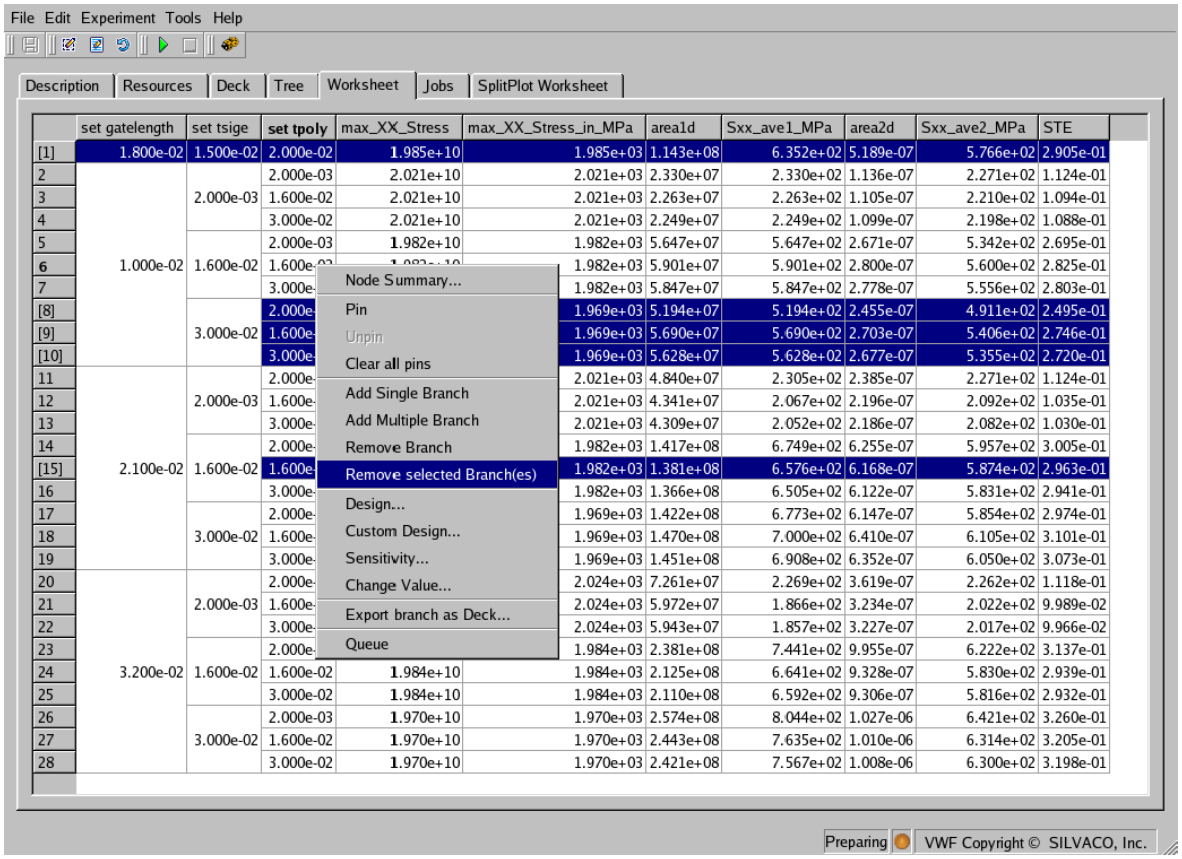
Figure 3-40 Experiment Editor – Worksheet tab

The worksheet can also be used to remove rows. Figure 3-41 shows a worksheet with several rows selected for removal. The selected rows are highlighted and the column number is drawn in brackets ([ ]). In this example, rows 1, 8, 9, 10, and 15 are selected. To select a row, click on the row header with the left mouse button. To select several rows, hold the Ctrl key and click on the row header of the row you want to add. Selected rows can be removed by right-clicking into the worksheet (Figure 3-42) or on the row heading (Figure 3-43) and selecting **Remove selected Branche(s)**.


tjlx2545.Silvaco.COM:vwfex01 - [DOE] (10040)
File Edit Experiment Tools Help
Description Resources Deck Tree Worksheet Jobs SplitPlot Worksheet
Preparing
VWF Copyright © SILVACO, Inc.

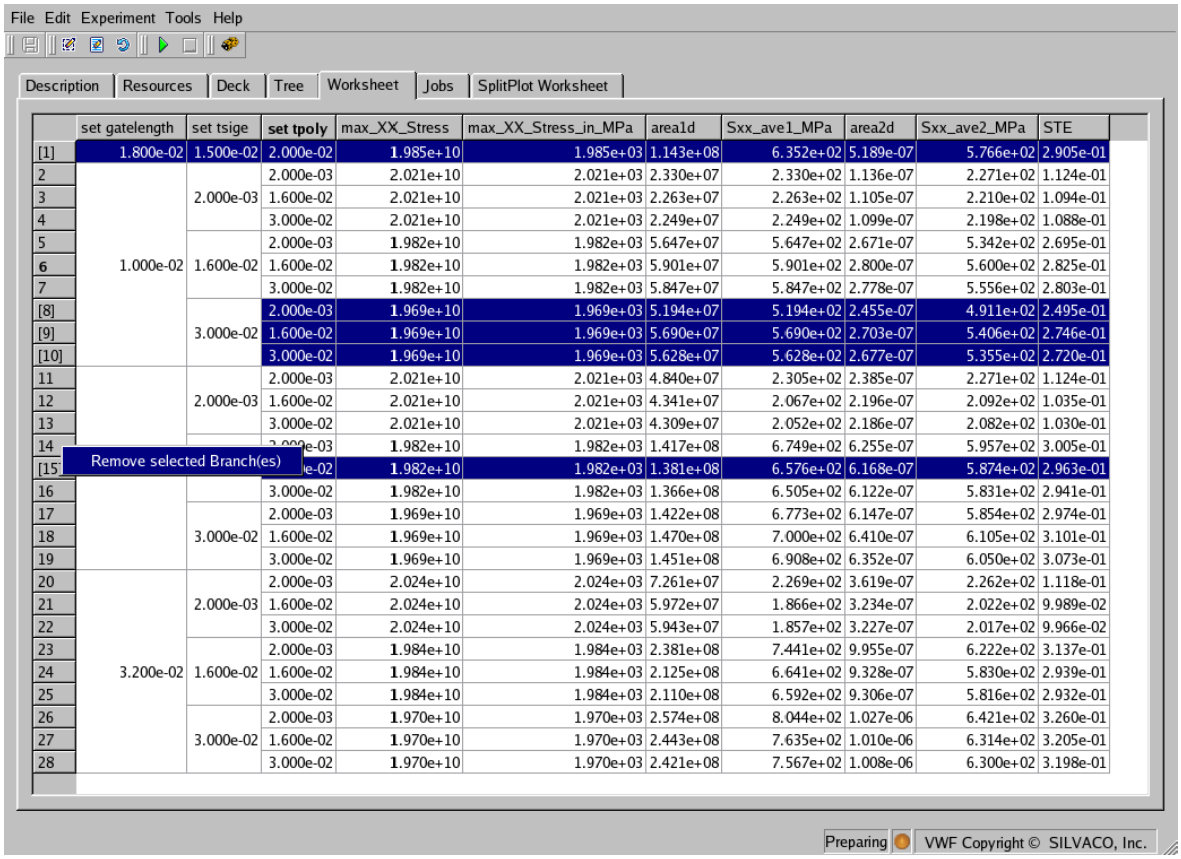
	set gatelength	set tsige	set tpoly	max_XX_Stress	max_XX_Stress_in_MPa	area1d	Sxx_ave1_MPa	area2d	Sxx_ave2_MPa	STE
[1]	1.800e-02	1.500e-02	2.000e-02	1.985e+10	1.985e+03	1.143e+08	6.352e+02	5.189e-07	5.766e+02	2.905e-01
2			2.000e-03	2.021e+10	2.021e+03	2.330e+07	2.330e+02	1.136e-07	2.271e+02	1.124e-01
3		2.000e-03	1.600e-02	2.021e+10	2.021e+03	2.263e+07	2.263e+02	1.105e-07	2.210e+02	1.094e-01
4			3.000e-02	2.021e+10	2.021e+03	2.249e+07	2.249e+02	1.099e-07	2.198e+02	1.088e-01
5			2.000e-03	1.982e+10	1.982e+03	5.647e+07	5.647e+02	2.671e-07	5.342e+02	2.695e-01
6	1.000e-02	1.600e-02	1.600e-02	1.982e+10	1.982e+03	5.901e+07	5.901e+02	2.800e-07	5.600e+02	2.825e-01
7			3.000e-02	1.982e+10	1.982e+03	5.847e+07	5.847e+02	2.778e-07	5.556e+02	2.803e-01
[8]			2.000e-03	1.969e+10	1.969e+03	5.194e+07	5.194e+02	2.455e-07	4.911e+02	2.495e-01
[9]		3.000e-02	1.600e-02	1.969e+10	1.969e+03	5.690e+07	5.690e+02	2.703e-07	5.406e+02	2.746e-01
[10]			3.000e-02	1.969e+10	1.969e+03	5.628e+07	5.628e+02	2.677e-07	5.355e+02	2.720e-01
11			2.000e-03	2.021e+10	2.021e+03	4.840e+07	2.305e+02	2.385e-07	2.271e+02	1.124e-01
12		2.000e-03	1.600e-02	2.021e+10	2.021e+03	4.341e+07	2.067e+02	2.196e-07	2.092e+02	1.035e-01
13			3.000e-02	2.021e+10	2.021e+03	4.309e+07	2.052e+02	2.186e-07	2.082e+02	1.030e-01
14			2.000e-03	1.982e+10	1.982e+03	1.417e+08	6.749e+02	6.255e-07	5.957e+02	3.005e-01
[15]	2.100e-02	1.600e-02	1.600e-02	1.982e+10	1.982e+03	1.381e+08	6.576e+02	6.168e-07	5.874e+02	2.963e-01
16			3.000e-02	1.982e+10	1.982e+03	1.366e+08	6.505e+02	6.122e-07	5.831e+02	2.941e-01
17			2.000e-03	1.969e+10	1.969e+03	1.422e+08	6.773e+02	6.147e-07	5.854e+02	2.974e-01
18		3.000e-02	1.600e-02	1.969e+10	1.969e+03	1.470e+08	7.000e+02	6.410e-07	6.105e+02	3.101e-01
19			3.000e-02	1.969e+10	1.969e+03	1.451e+08	6.908e+02	6.352e-07	6.050e+02	3.073e-01
20			2.000e-03	2.024e+10	2.024e+03	7.261e+07	2.269e+02	3.619e-07	2.262e+02	1.118e-01
21		2.000e-03	1.600e-02	2.024e+10	2.024e+03	5.972e+07	1.866e+02	3.234e-07	2.022e+02	9.989e-02
22			3.000e-02	2.024e+10	2.024e+03	5.943e+07	1.857e+02	3.227e-07	2.017e+02	9.966e-02
23			2.000e-03	1.984e+10	1.984e+03	2.381e+08	7.441e+02	9.955e-07	6.222e+02	3.137e-01
24	3.200e-02	1.600e-02	1.600e-02	1.984e+10	1.984e+03	2.125e+08	6.641e+02	9.328e-07	5.830e+02	2.939e-01
25			3.000e-02	1.984e+10	1.984e+03	2.110e+08	6.592e+02	9.306e-07	5.816e+02	2.932e-01
26			2.000e-03	1.970e+10	1.970e+03	2.574e+08	8.044e+02	1.027e-06	6.421e+02	3.260e-01
27		3.000e-02	1.600e-02	1.970e+10	1.970e+03	2.443e+08	7.635e+02	1.010e-06	6.314e+02	3.205e-01
28			3.000e-02	1.970e+10	1.970e+03	2.421e+08	7.567e+02	1.008e-06	6.300e+02	3.198e-01

Figure 3-41 Several Rows Highlighted for Removal



	set gatelength	set tsige	set tpoly	max_XX_Stress	max_XX_Stress_in_MPa	area1d	Sxx_ave1_MPa	area2d	Sxx_ave2_MPa	STE
[1]	1.800e-02	1.500e-02	2.000e-02	1.985e+10	1.985e+03	1.143e+08	6.352e+02	5.189e-07	5.766e+02	2.905e-01
2			2.000e-03	2.021e+10	2.021e+03	2.330e+07	2.330e+02	1.136e-07	2.271e+02	1.124e-01
3		2.000e-03	1.600e-02	2.021e+10	2.021e+03	2.263e+07	2.263e+02	1.105e-07	2.210e+02	1.094e-01
4			3.000e-02	2.021e+10	2.021e+03	2.249e+07	2.249e+02	1.099e-07	2.198e+02	1.088e-01
5			2.000e-03	1.982e+10	1.982e+03	5.647e+07	5.647e+02	2.671e-07	5.342e+02	2.695e-01
6	1.000e-02	1.600e-02	1.600e-	1.982e+10	1.982e+03	5.901e+07	5.901e+02	2.800e-07	5.600e+02	2.825e-01
7			3.000e-		1.982e+03	5.847e+07	5.847e+02	2.778e-07	5.556e+02	2.803e-01
[8]			2.000e-		1.969e+03	5.194e+07	5.194e+02	2.455e-07	4.911e+02	2.495e-01
[9]		3.000e-02	1.600e-		1.969e+03	5.690e+07	5.690e+02	2.703e-07	5.406e+02	2.746e-01
[10]			3.000e-		1.969e+03	5.628e+07	5.628e+02	2.677e-07	5.355e+02	2.720e-01
11			2.000e-		2.021e+03	4.840e+07	2.305e+02	2.385e-07	2.271e+02	1.124e-01
12		2.000e-03	1.600e-		2.021e+03	4.341e+07	2.067e+02	2.196e-07	2.092e+02	1.035e-01
13			3.000e-		2.021e+03	4.309e+07	2.052e+02	2.186e-07	2.082e+02	1.030e-01
14			2.000e-		1.982e+03	1.417e+08	6.749e+02	6.255e-07	5.957e+02	3.005e-01
[15]	2.100e-02	1.600e-02	1.600e-		1.982e+03	1.381e+08	6.576e+02	6.168e-07	5.874e+02	2.963e-01
16			3.000e-		1.982e+03	1.366e+08	6.505e+02	6.122e-07	5.831e+02	2.941e-01
17			2.000e-		1.969e+03	1.422e+08	6.773e+02	6.147e-07	5.854e+02	2.974e-01
18		3.000e-02	1.600e-		1.969e+03	1.470e+08	7.000e+02	6.410e-07	6.105e+02	3.101e-01
19			3.000e-		1.969e+03	1.451e+08	6.908e+02	6.352e-07	6.050e+02	3.073e-01
20			2.000e-		2.024e+03	7.261e+07	2.269e+02	3.619e-07	2.262e+02	1.118e-01
21		2.000e-03	1.600e-		2.024e+03	5.972e+07	1.866e+02	3.234e-07	2.022e+02	9.989e-02
22			3.000e-		2.024e+03	5.943e+07	1.857e+02	3.227e-07	2.017e+02	9.966e-02
23			2.000e-		1.984e+03	2.381e+08	7.441e+02	9.955e-07	6.222e+02	3.137e-01
24	3.200e-02	1.600e-02	1.600e-02	1.984e+10	1.984e+03	2.125e+08	6.641e+02	9.328e-07	5.830e+02	2.939e-01
25			3.000e-02	1.984e+10	1.984e+03	2.110e+08	6.592e+02	9.306e-07	5.816e+02	2.932e-01
26			2.000e-03	1.970e+10	1.970e+03	2.574e+08	8.044e+02	1.027e-06	6.421e+02	3.260e-01
27		3.000e-02	1.600e-02	1.970e+10	1.970e+03	2.443e+08	7.635e+02	1.010e-06	6.314e+02	3.205e-01
28			3.000e-02	1.970e+10	1.970e+03	2.421e+08	7.567e+02	1.008e-06	6.300e+02	3.198e-01

Figure 3-42 Initiating Row Removal via Context Menu



	set gatelength	set tsige	set tpoly	max_XX_Stress	max_XX_Stress_in_MPa	area1d	Sxx_ave1_MPa	area2d	Sxx_ave2_MPa	STE
[1]	1.800e-02	1.500e-02	2.000e-02	1.985e+10	1.985e+03	1.143e+08	6.352e+02	5.189e-07	5.766e+02	2.905e-01
2			2.000e-03	2.021e+10	2.021e+03	2.330e+07	2.330e+02	1.136e-07	2.271e+02	1.124e-01
3		2.000e-03	1.600e-02	2.021e+10	2.021e+03	2.263e+07	2.263e+02	1.105e-07	2.210e+02	1.094e-01
4			3.000e-02	2.021e+10	2.021e+03	2.249e+07	2.249e+02	1.099e-07	2.198e+02	1.088e-01
5			2.000e-03	1.982e+10	1.982e+03	5.647e+07	5.647e+02	2.671e-07	5.342e+02	2.695e-01
6	1.000e-02	1.600e-02	1.600e-02	1.982e+10	1.982e+03	5.901e+07	5.901e+02	2.800e-07	5.600e+02	2.825e-01
7			3.000e-02	1.982e+10	1.982e+03	5.847e+07	5.847e+02	2.778e-07	5.556e+02	2.803e-01
[8]			2.000e-03	1.969e+10	1.969e+03	5.194e+07	5.194e+02	2.455e-07	4.911e+02	2.495e-01
[9]		3.000e-02	1.600e-02	1.969e+10	1.969e+03	5.690e+07	5.690e+02	2.703e-07	5.406e+02	2.746e-01
[10]			3.000e-02	1.969e+10	1.969e+03	5.628e+07	5.628e+02	2.677e-07	5.355e+02	2.720e-01
11			2.000e-03	2.021e+10	2.021e+03	4.840e+07	2.305e+02	2.385e-07	2.271e+02	1.124e-01
12		2.000e-03	1.600e-02	2.021e+10	2.021e+03	4.341e+07	2.067e+02	2.196e-07	2.092e+02	1.035e-01
13			3.000e-02	2.021e+10	2.021e+03	4.309e+07	2.052e+02	2.186e-07	2.082e+02	1.030e-01
14				1.982e+10	1.982e+03	1.417e+08	6.749e+02	6.255e-07	5.957e+02	3.005e-01
[15			e-02	1.982e+10	1.982e+03	1.381e+08	6.576e+02	6.168e-07	5.874e+02	2.963e-01
16			3.000e-02	1.982e+10	1.982e+03	1.366e+08	6.505e+02	6.122e-07	5.831e+02	2.941e-01
17			2.000e-03	1.969e+10	1.969e+03	1.422e+08	6.773e+02	6.147e-07	5.854e+02	2.974e-01
18		3.000e-02	1.600e-02	1.969e+10	1.969e+03	1.470e+08	7.000e+02	6.410e-07	6.105e+02	3.101e-01
19			3.000e-02	1.969e+10	1.969e+03	1.451e+08	6.908e+02	6.352e-07	6.050e+02	3.073e-01
20			2.000e-03	2.024e+10	2.024e+03	7.261e+07	2.269e+02	3.619e-07	2.262e+02	1.118e-01
21		2.000e-03	1.600e-02	2.024e+10	2.024e+03	5.972e+07	1.866e+02	3.234e-07	2.022e+02	9.989e-02
22			3.000e-02	2.024e+10	2.024e+03	5.943e+07	1.857e+02	3.227e-07	2.017e+02	9.966e-02
23			2.000e-03	1.984e+10	1.984e+03	2.381e+08	7.441e+02	9.955e-07	6.222e+02	3.137e-01
24	3.200e-02	1.600e-02	1.600e-02	1.984e+10	1.984e+03	2.125e+08	6.641e+02	9.328e-07	5.830e+02	2.939e-01
25			3.000e-02	1.984e+10	1.984e+03	2.110e+08	6.592e+02	9.306e-07	5.816e+02	2.932e-01
26			2.000e-03	1.970e+10	1.970e+03	2.574e+08	8.044e+02	1.027e-06	6.421e+02	3.260e-01
27		3.000e-02	1.600e-02	1.970e+10	1.970e+03	2.443e+08	7.635e+02	1.010e-06	6.314e+02	3.205e-01
28			3.000e-02	1.970e+10	1.970e+03	2.421e+08	7.567e+02	1.008e-06	6.300e+02	3.198e-01

Figure 3-43 Initiating Row Removal by right-clicking on Row Header

3.3.4 Formatting Cells in the Worksheet

You can influence the way how the content of cells in the worksheet is formatted. The format is defined together with the settings in the Preferences panel and follows the rules below.

- In the Preferences panel, you can define a format common to all cells in the worksheet.
- Columns can be formatted individually. This overrules any setting defined in preferences.

For formats defined in preferences, please refer to Chapter 4 “Customizing VWF – Preferences Panel”.

An individual format for a column is defined by right-clicking on the header of that column. Figure 3-44 displays the menu entry to open the format dialog.

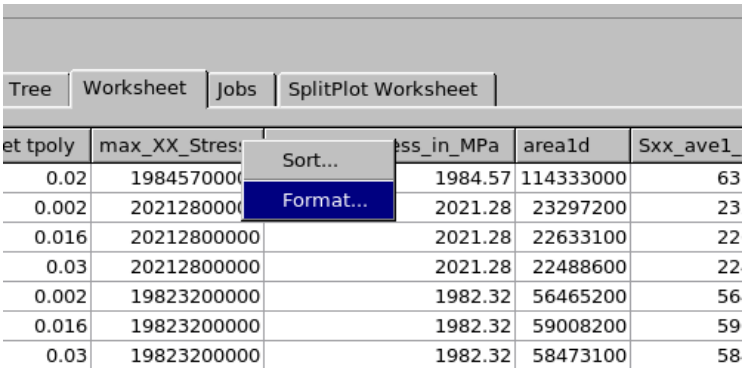


Figure 3-44 Context Menu to Open Format Dialog

Figure 3-45 displays the dialog to enter the format. In this example, the format for the column named **max_XX_Stress** is defined. The name of the column to format is indicated in the dialog header. You define the format by selecting one of the entries of the **Formatting** menu. If no format was defined for this column so far, the selection shows **Automatic**. This means the format to apply is chosen according to the **Preferences** setting.

Below the **Formatting** menu, there’s an area called **Preview**. This gives a preview of how a particular format will look when applied. You can enter an arbitrary value in the value field to experiment with the format you defined. The display field is updated immediately whenever you change value or format.

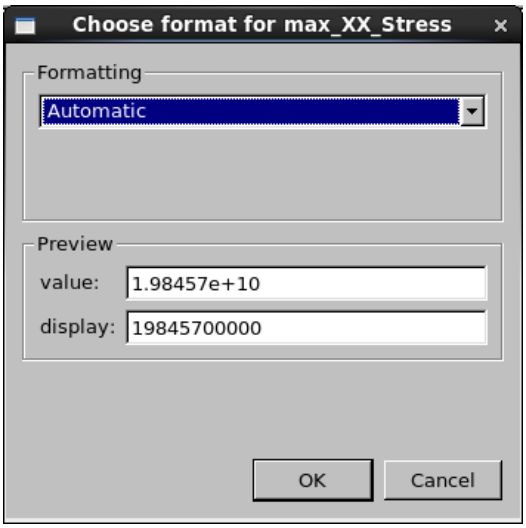


Figure 3-45 Define Worksheet Column Format

Figure 3-46 depicts the content of the **Formatting** pull-down menu. You are presented with the following choices:

- **Automatic** – Applies an automatic format to that column. This is the default if no format for a column has been selected so far.
- **Floating point** – Formats the number according to the defined precision.
- **Scientific** – Numbers are displayed in scientific notation.
- **Custom** – Allows to define a custom format using the syntax as used in the printf C-function.

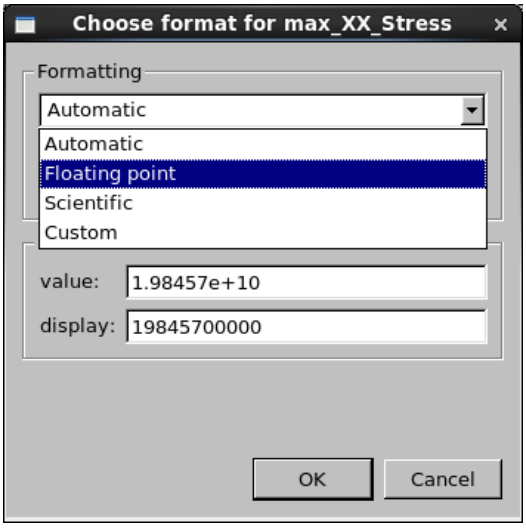


Figure 3-46 Available Column Formats

Figure 3-47 displays the setting in case the **Floating point** format was chosen. An extra field **Precision** appears where you can define the number of digits to display. In the depicted screen-shot, a value of 6 is selected for **Precision**. Note that this is also reflected in the **Preview**.

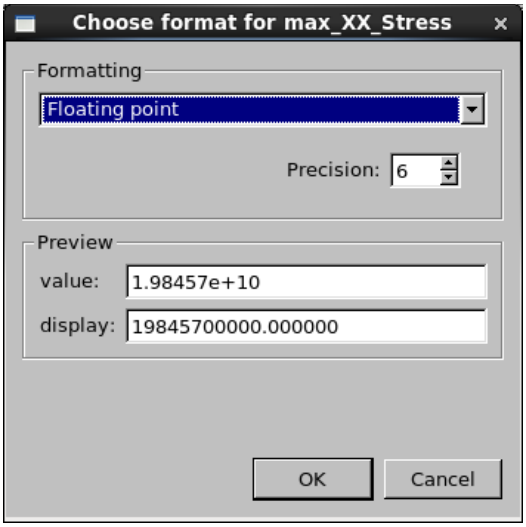


Figure 3-47 Floating Point Format

Figure 3-48 shows the dialog for the **Scientific** notation. Again, the **Precision** field can be used to define the number of digits to display.

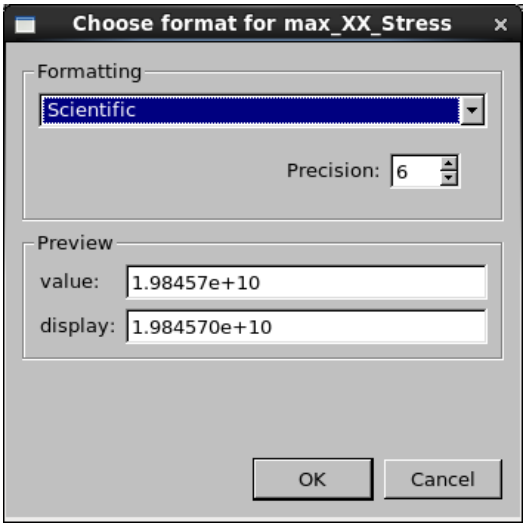


Figure 3-48 Scientific Format

Finally, Figure 3-49 displays the dialog for the **Custom** format type. Instead of the **Precision** field, there is now a field called **format string**. It allows you to enter a C-type format string. Please note that the usage of the custom format type is considered an advanced feature. Care was taken to restrict the format string to floating point formats. An error is displayed in case an illegal format string is entered. Figure 3-50 displays the situation where an illegal format string (%s) was entered. The entered format is not accepted in this case and the **OK** button is grayed.

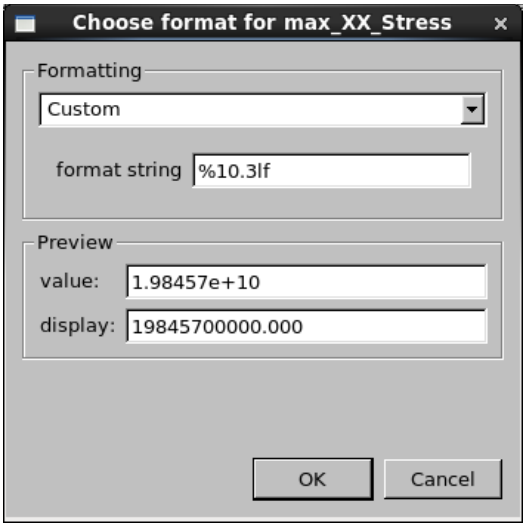


Figure 3-49 Custom Format

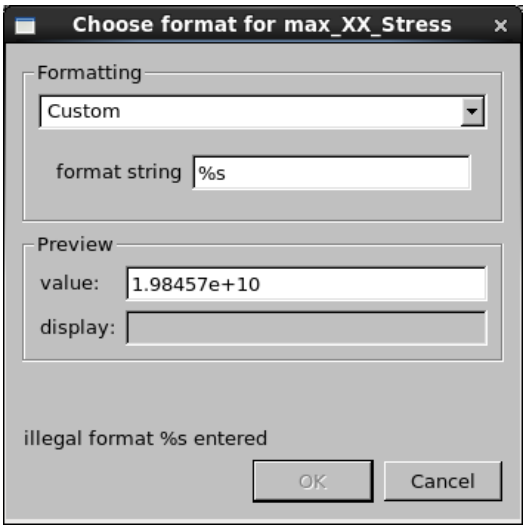


Figure 3-50 Illegal Format was Entered

3.3.5 Defining Splits

There are several ways of entering split points. The most convenient way is to select one of the predefined DOE designs as shown in Figure 3-51.

The DOE design dialog (Figure 3-51) can be opened by right-clicking on any of the lines in the worksheet and selecting **Design** from the context menu. The dialog allows you to select one of several designs by using the drop down menu. Figure 3-51 shows a **2 Level Full Factorial** with no parameters selected yet. To complete the definition of the DOE design, you have to select which parameters to use and you have to define the lower and upper bounds for each selected parameter. After clicking **OK**, the shown design strategy will insert one node for the upper and one node for the lower boundary of the selected parameter values. For a total of n parameters 2^n branches are entered into the worksheet. The depicted initial value is the one that is existing in the deck. By confirming the data with **OK**, the worksheet is updated with the new branches.

Adding splits by using a design can be repeated several times in order to add more branches to the worksheet. The buttons labeled **Replace Existing** and **Add** to existing allow you to decide whether a worksheet will be overwritten with the new design or whether the values will be appended to the splits that are already in the worksheet. Note, however, that you cannot use this technique to duplicate splits by applying the same design several times. No new values will be added in this case even when you select **Add to existing**. This is because VWF compares the newly created splits with the splits already in the worksheet and will only add unique splits.

Note: Only **Double** valued parameter types can be used in the Design dialog. All other parameter types are grayed out.

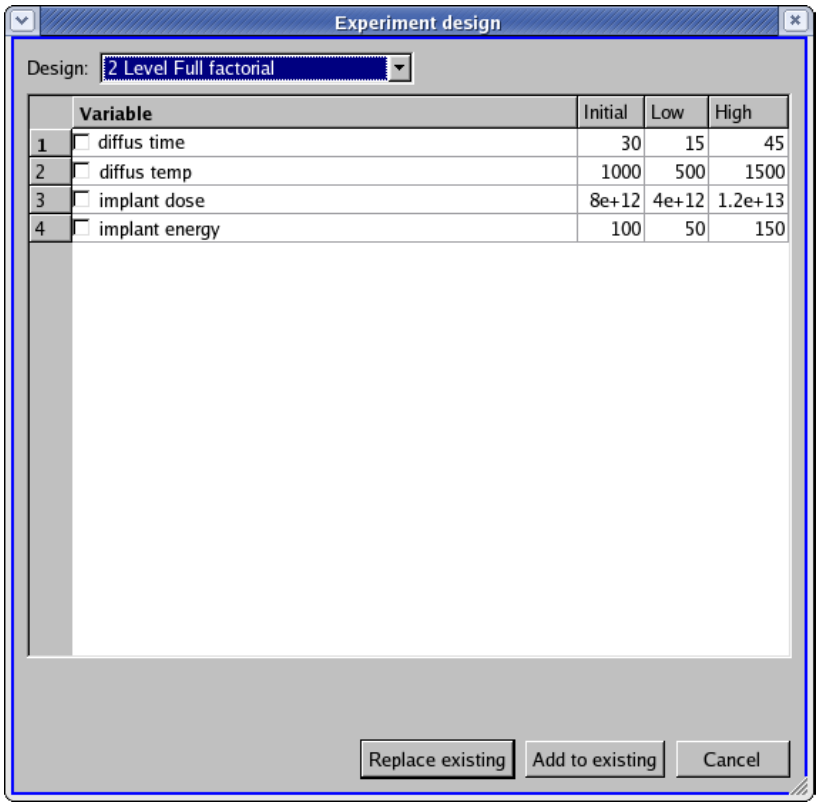


Figure 3-51 DOE Design Dialog showing 2 Level Full Factorial Design

Other design strategies are available as well. In the experiment shown in Figure 3-52, a Box-Behnken design with 12 parameters selected is given. Figure 3-53 shows the tree, which results from this design.

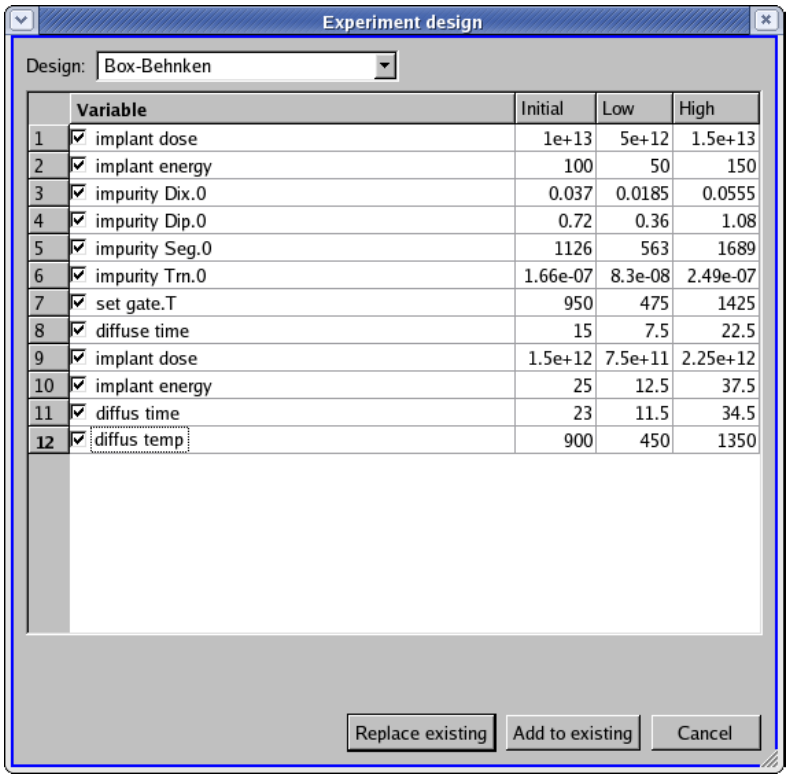

Experiment design
Design: Box-Behnken
Variable
Initial
Low
High
1 implant dose 1e+13 5e+12 1.5e+13
2 implant energy 100 50 150
3 impurity Dix.0 0.037 0.0185 0.0555
4 impurity Dip.0 0.72 0.36 1.08
5 impurity Seg.0 1126 563 1689
6 impurity Trn.0 1.66e-07 8.3e-08 2.49e-07
7 set gate.T 950 475 1425
8 diffuse time 15 7.5 22.5
9 implant dose 1.5e+12 7.5e+11 2.25e+12
10 implant energy 25 12.5 37.5
11 diffus time 23 11.5 34.5
12 diffus temp 900 450 1350
Replace existing
Add to existing
Cancel

Figure 3-52 Box-Behnken DOE Design with 12 Parameters

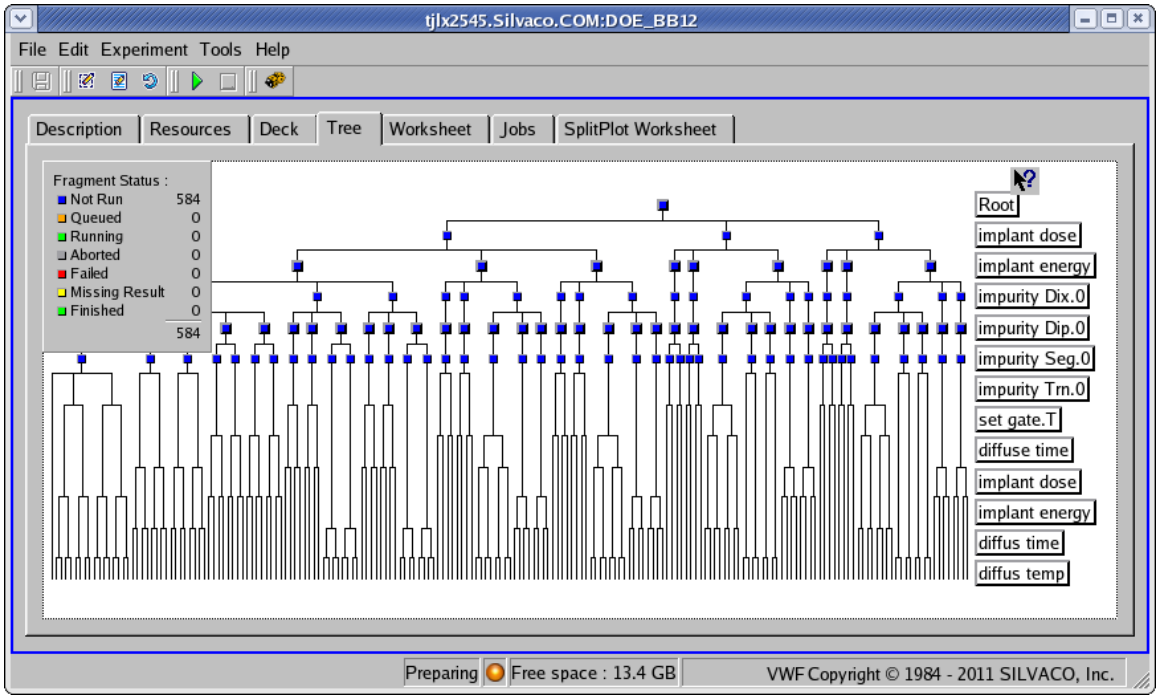


Figure 3-53 Tree Resulting from Applied Box-Behnken Design

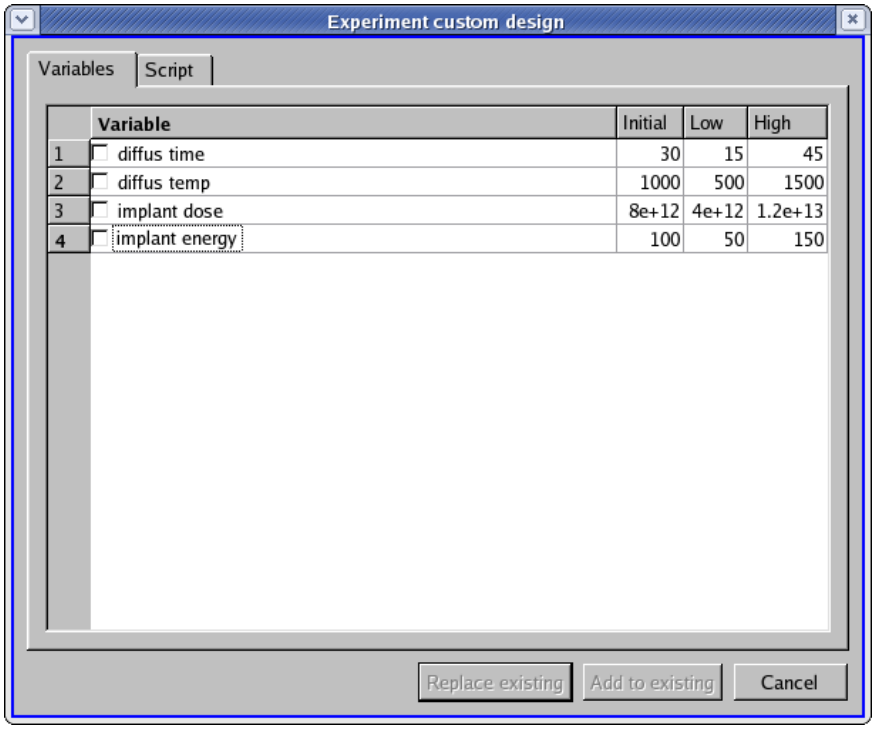


Figure 3-54 Custom Design Dialog

Instead of using a pre-defined DOE strategy, you can opt to use a JavaScript program to define an arbitrary strategy. Use the **Custom Design** entry of the context menu, which opens by right-clicking on any of the lines in the worksheet. Figure 3-54 shows this dialog. As with the regular Design Dialog (Figure 3-51), you need to select which parameters you want to use in the DOE. This is done in the **Variables** pane of the dialog. After selecting the parameters, click on the **Script** pane (see Figure 3-55). Here, an example script of an advanced latin-hypercube algorithm was loaded. Please refer to Chapter 7 “Scripting in VWF” for full details of the VWF scripting interface.

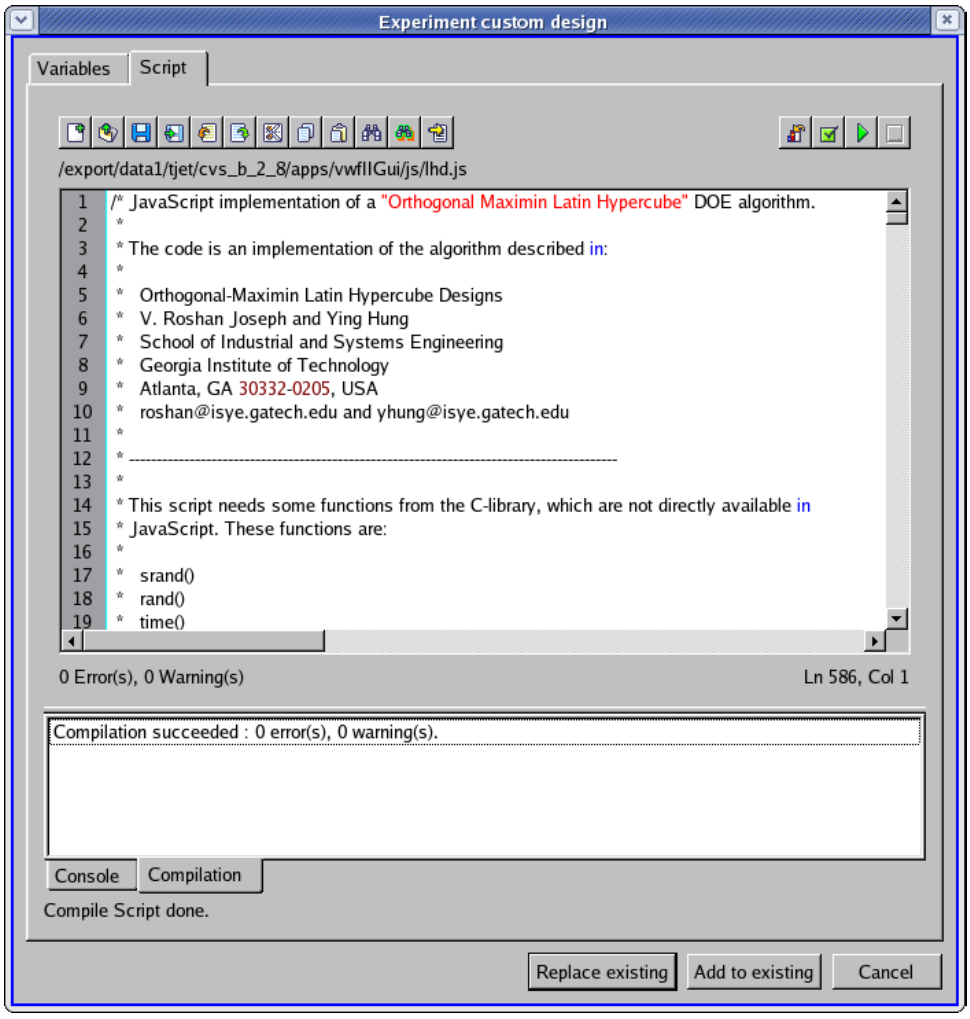

Experiment custom design
Variables
Script
/export/data1/tjet/cvs_b_2_8/apps/vwfIIGui/js/lhd.js
1 /* JavaScript implementation of a "Orthogonal Maximin Latin Hypercube" DOE algorithm.
2 *
3 * The code is an implementation of the algorithm described in:
4 *
5 * Orthogonal-Maximin Latin Hypercube Designs
6 * V. Roshan Joseph and Ying Hung
7 * School of Industrial and Systems Engineering
8 * Georgia Institute of Technology
9 * Atlanta, GA 30332-0205, USA
10 * roshan@isye.gatech.edu and yhung@isye.gatech.edu
11 *
12 * ----------
13 *
14 * This script needs some functions from the C-library, which are not directly available in
15 * JavaScript. These functions are:
16 *
17 * srand()
18 * rand()
19 * time()
0 Error(s), 0 Warning(s)
Ln 586, Col 1
Compilation succeeded : 0 error(s), 0 warning(s).
Console
Compilation
Compile Script done.
Replace existing
Add to existing
Cancel

Figure 3-55 Custom Design Dialog – Script pane

After defining a tree with the regular or the Custom Design Dialog, you must select which jobs to simulate. This can either be the whole lot or a manually selected subset.

In order to reduce execution time of experiments, simulations are carried out in parallel. To achieve a maximum of parallelization, simulation jobs are delegated to an underlying job farming system (a grid). This version of VWF supports two types of job farming. One is a built-in system called the Silvaco Simple Queue. It limits execution of simulations to the local machine but can utilize all CPUs on this machine (for SMP machines). This queue is best

used if VWF is to be run on a single workstation. No extra grid software needs to be installed. The second type of systems are networked grid computing facilities. They allow you to run simulation jobs on a cluster of workstations and are supported through the Distributed Resource Management Application API (DRMAA) sub-system. DRMAA is supported by several vendors of grid computing systems. In VWF, two systems are available: one is the Open Grid Scheduler (OGS), the other is the Load Sharing Facility (LSF). Both systems allow you to define an arbitrary number of nodes of workstations. OGS is open domain and presents sophisticated scheduling algorithms. It allows you to define fine-grained rules of how jobs are selected for execution (e.g., based on the CPU load on a given node), or at what time a machine is available (e.g., locked during working hours but available for simulation jobs during the night or at weekends). LSF is a commercial software package. Neither OGS nor LSF are not deployed together with the VWF software. These packages must be obtained and installed separately. See the quickstart guide in Appendix B “Queuing VWF On The Oracle/SUN Grid Engine/ Open Grid Scheduler” on how to obtain and install the OGS software.

Note: A detailed description of the OGS concepts and installation procedures and scenarios is beyond the scope of this manual. An overview of the installation process is given in Appendix B “Queuing VWF On The Oracle/SUN Grid Engine/ Open Grid Scheduler”.

The queue, which will be used for executing simulation jobs, must be selected in the Preferences dialog of VWF prior to starting the experiment and cannot be changed for running experiments. Select one of the two available options local (**Silvaco Simple Queue**) or DRMAA (**OGS** or **LSF**). The selection of the queuing system is stored persistently together with other settings in a preferences file in the user's home directory.

Note: Parallel should be distinguished from multi-threaded. Multi-threading refers to utilizing several CPUs in a single simulation job, whereas parallel refers to running several simulation jobs each on a different CPU at a time.

Figure 3-56 shows the **Experiment** menu. By selecting **Experiment→Start**, the experiment as defined in the steps above will be started. If the experiment has unsaved changes, you will first be prompted to save the experiment (Figure 3-57). If no jobs have been selected for simulation, you will also be prompted to add all jobs to the queue of simulation jobs (Figure 3-58). Upon clicking **OK**, all jobs will be added to the queue.

Selecting **Experiment→Stop** will terminate a running experiment. It is not available (grayed) if the experiment is not running. All jobs, which are currently queued are removed from the queue, and their state is set to aborted. Additionally, all jobs that are currently running are terminated with a state of aborted.

Selecting **Experiment→Clear All Results** will remove all results of this experiment. Results consist of data in the worksheet and result files, which were created during a simulation run. If you only want to remove the simulation result files (e.g., to save on disk space) but want to keep the worksheet data, you can select **Experiment→Clear Result Files**. Both entries are only available if the experiment is not currently running.

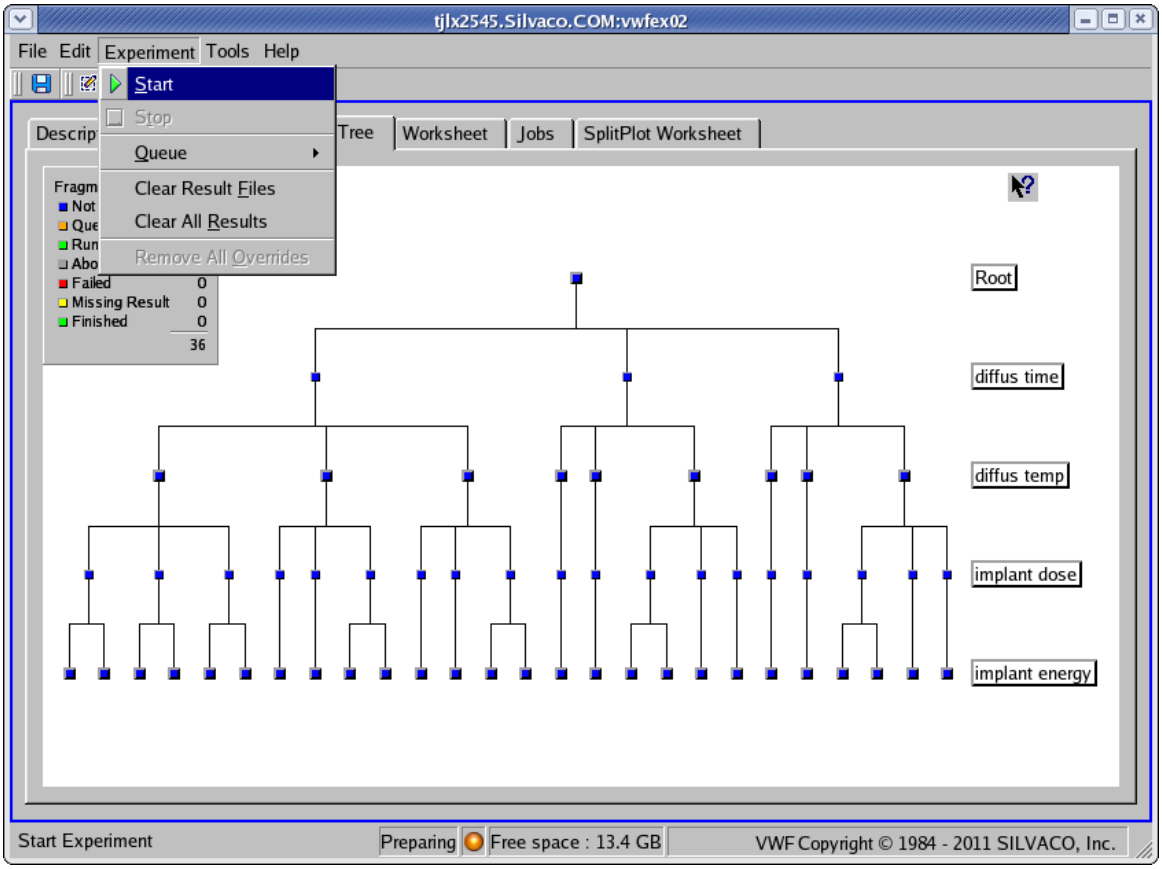


Figure 3-56 Start Experiment Menu Entry

Figure 3-57 Prompt to save changes

Figure 3-58 Prompt to add all jobs

Figure 3-59 shows the menu entry to add only some of the available jobs to the queue. Jobs to add must be selected using the mouse. The selected jobs are surrounded by red rectangles. If jobs are added using this menu entry, the experiment must be started (**Experiment→Start**) in a separate step and after jobs have been added. Jobs can also be added after an experiment has been started and while jobs are being executed. Other entries in this menu allow you to add jobs according to their state:

- **Selected** – Adds all jobs into the queue that have been selected using the mouse (surrounded by red rectangles).
- **Not Run** – Adds jobs that have not run yet.
- **Aborted** – Adds all jobs that were aborted. Aborted means that you have stopped the experiment by selecting **Experiment→Stop** (see Figure 3-60).
- **Failed** – Adds all jobs that crashed in a previous run. This is useful if, for instance, simulations don't produce any results (e.g., due to convergence problems in the underlying simulator) and you want to change numerical parameters in the deck and re-run those simulations.
- **Missing results** – Sometimes, a simulation does not produce all requested results but only a subset thereof. This menu entry allows you to rerun such simulations.

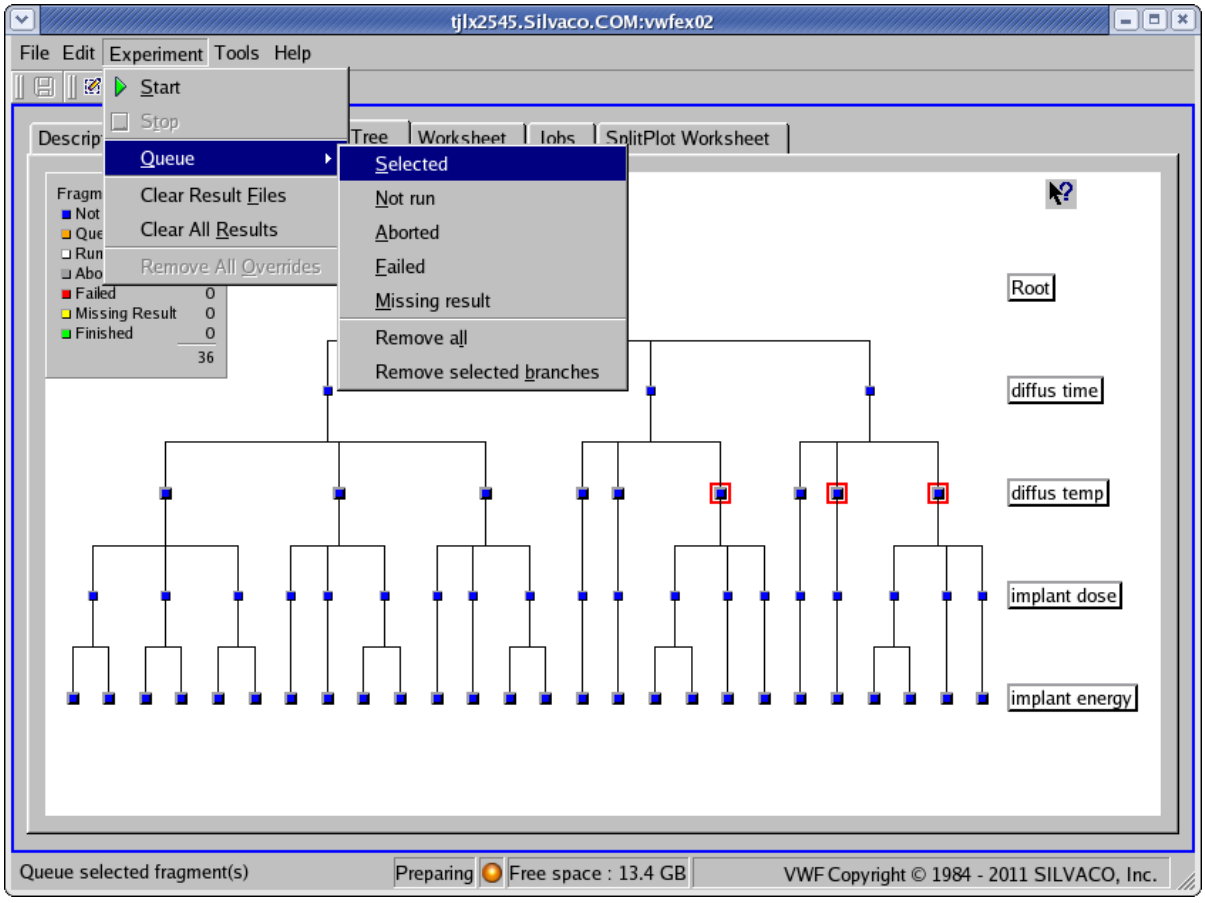


Figure 3-59 Queue selected

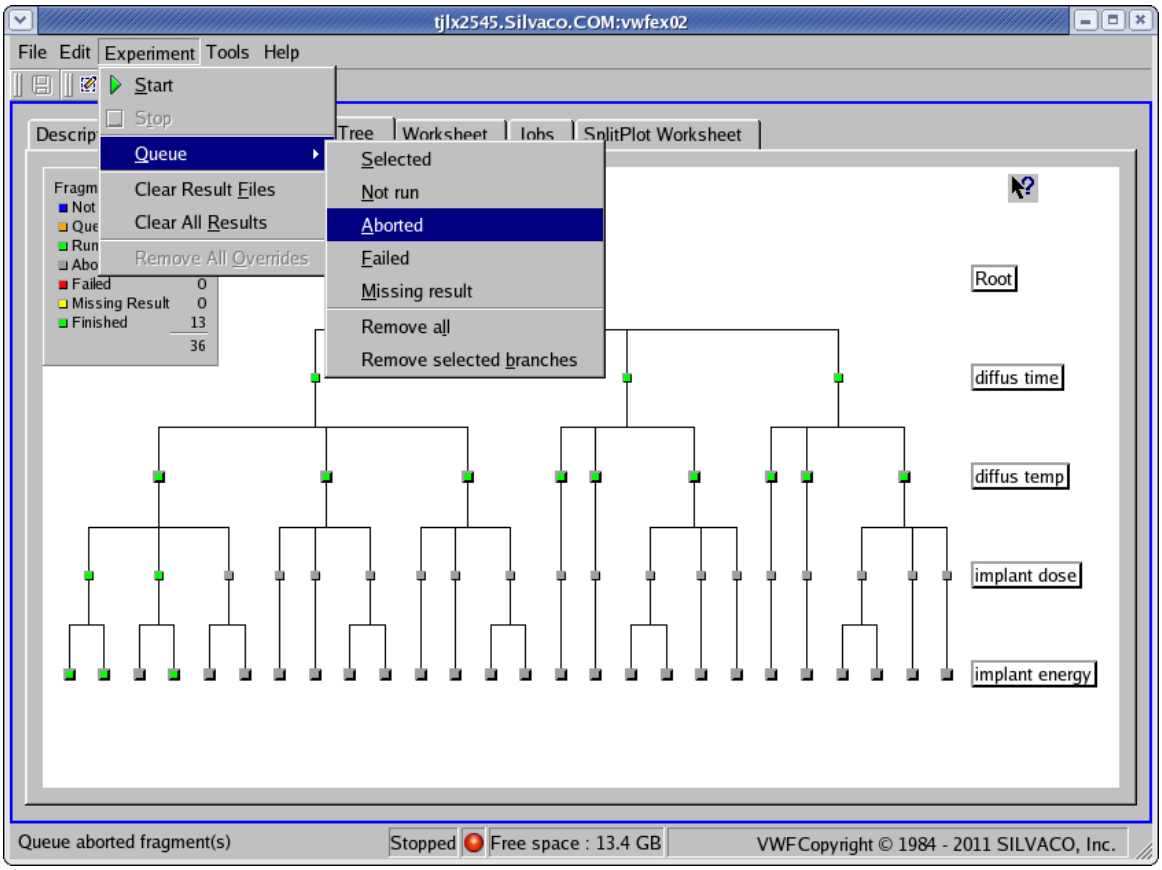


Figure 3-60 Queue aborted

It is not until the experiment has been started that jobs are actually handed over to the underlying queuing system. At this stage, the queuing system decides when jobs are executed and how many jobs are executed at the same time. You cannot control this directly from VWF. Figure 3-61 shows an example of a running experiment with 7 finished (green), 2 running (white), and 17 queued (orange) fragments. As jobs are finished, new jobs will be taken from the list of queued jobs and will be started. Figure 3-62 depicts another example where some jobs have failed (red) and some jobs have missing results (yellow).

A simulation job is a single simulation that is executed on a CPU. A fragment, however, is a more logical term and identifies a branch in the split tree. By selectively simulating only sub-branches of the tree and reusing outputs of one branch as input for another, the total execution time of an experiment can be drastically reduced. You can think of such an evaluation as a multi-leveled evaluation with levels spanning vertically between split parameters in the split tree. In the example shown in Figures 3-60 and 3-61, the first level only includes the top of the tree. The simulated deck fragment is the deck code from the beginning up to (but excluding) the first split parameter called `diffus time`. The second level would reach from `diffus time` up to (and including) `diffus temp`. Please note the rendering of thick and thin nodes on this level indicating that both parameters are on a single line (or on a non-splittable portion of deck). The third and last level reaches from one line below `diffus time` to `implant energy`. Again, thick and thin nodes indicate that the two parameters are on the same line of deck.

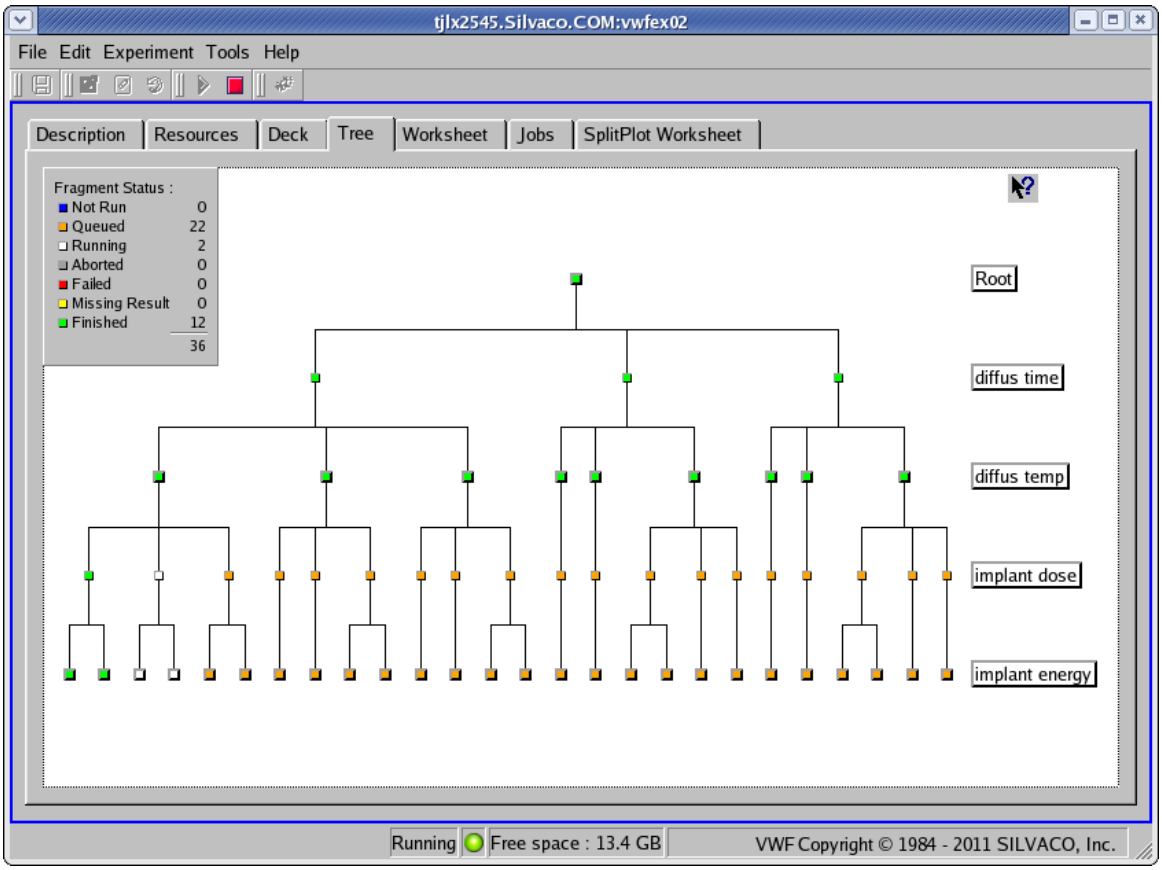


Figure 3-61 Job status – tree view

Note: There can be unwanted side effects regarding performance when splitting on set variables. VWF creates fragments based on where a split variable is defined. For `set` statements, the split location can differ from where the variable is actually used. For instance, if you define a split on a set (e.g., `set depth=0.5`) variable, which occurs at the beginning of the deck but is used further down (`$depth`), then the deck is still fragmented at the split definition (where the set occurs) and not at the location where it is used (`$depth`). In this case, you may not achieve the desired speed up that normally occurs from a hierarchical (multi-level) simulation.

Note: Once an experiment has been run and results are available, the deck will be locked automatically. This is indicated by the background of the slider bar shown in red. No changes can be made in a locked deck. The deck can be manually unlocked by clicking on the little padlock icon shown right above the deck pane. Unlocking and editing a deck has the effect of results being removed. This is to avoid situations where a changed deck no longer corresponds to the results obtained from a previous run. If you want to keep results, it is suggested to copy and paste the experiment and edit the copy instead of the original.

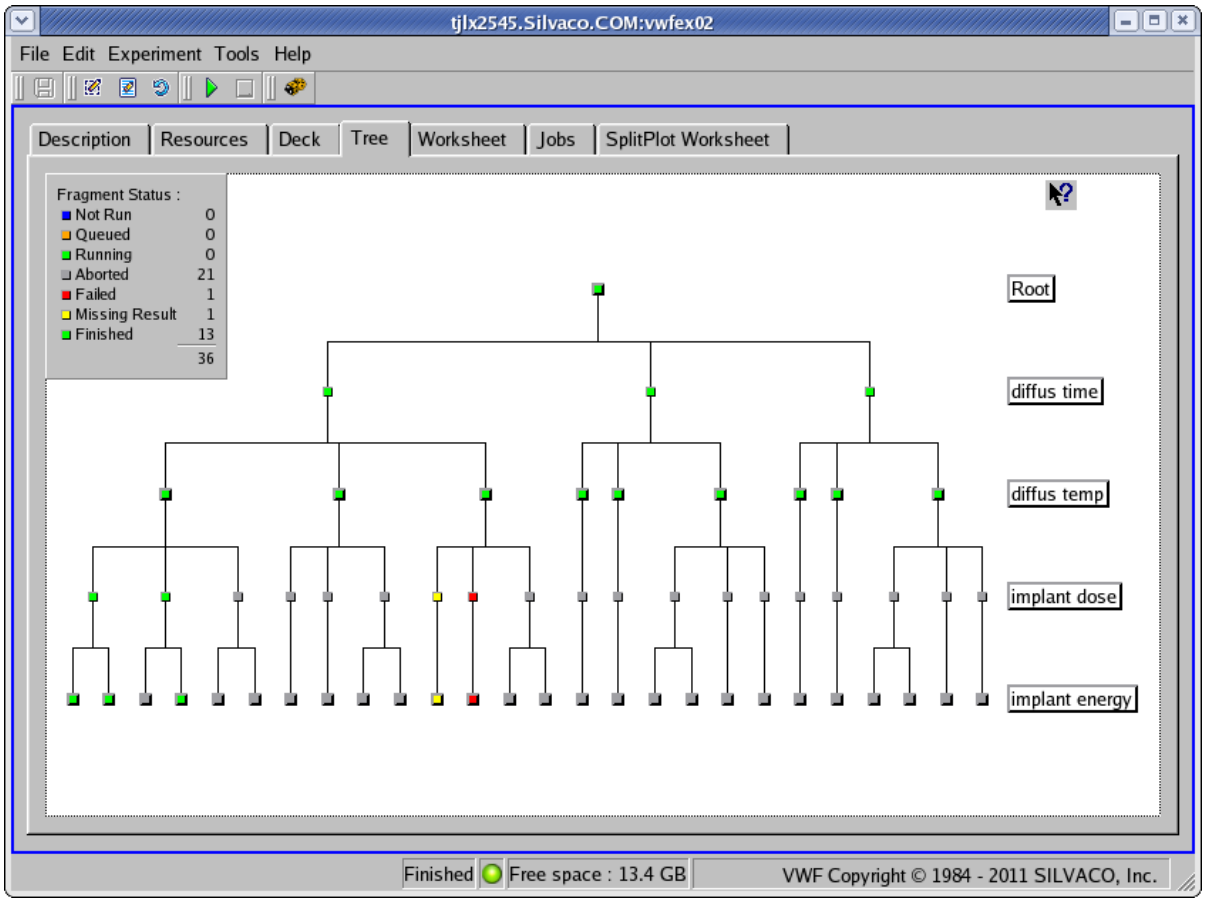


Figure 3-62 Job status – failed jobs

Job status information is not only displayed in the tree pane but also in the **Jobs** pane. Figure 3-63 depicts the **Jobs** pane. It shows a total of 10 jobs where 1 has been finished, 2 are running, and 7 are queued. The column **Id** depicts the job ids as assigned by the queuing system. In case you are using the grid-engine systems, these job ids will also show up in the `qmon` utility.

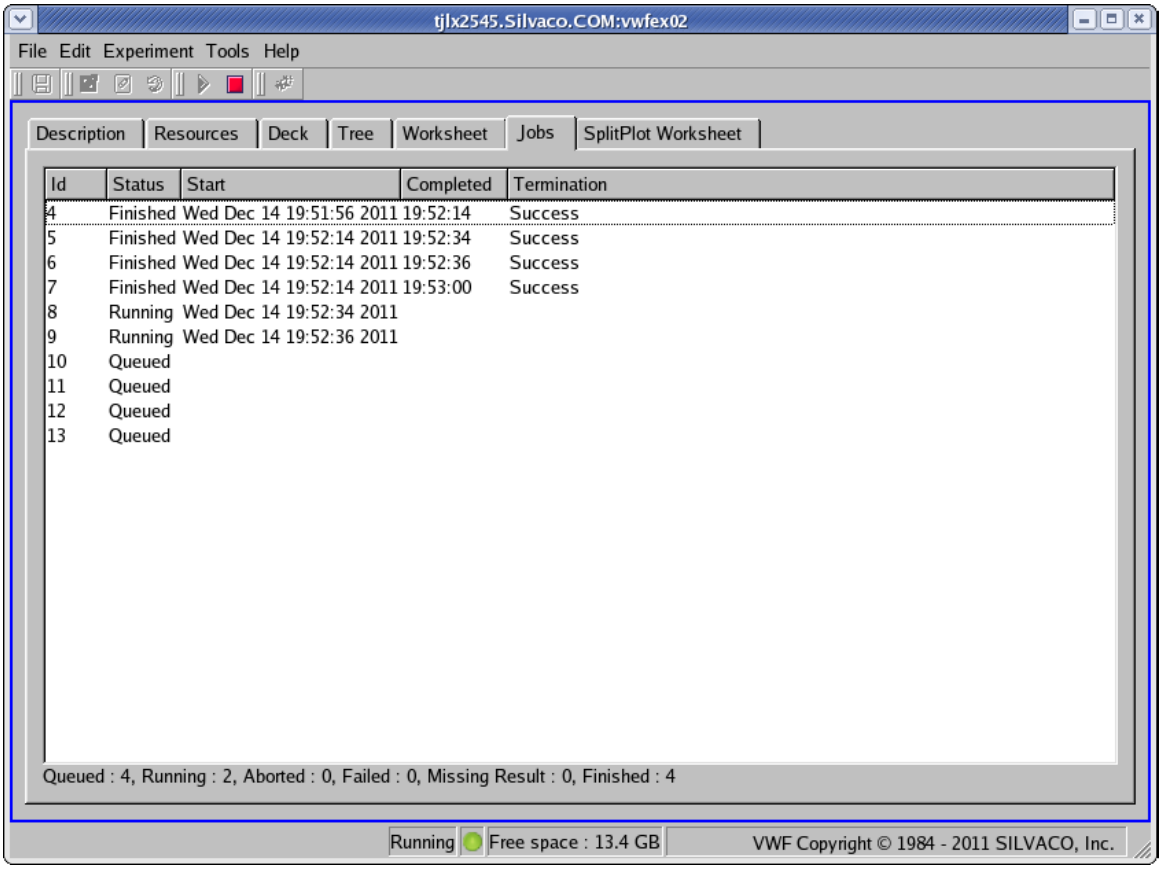

tjlx2545.Silvaco.COM:vwfex02
File Edit Experiment Tools Help
Description Resources Deck Tree Worksheet Jobs SplitPlot Worksheet
Id Status Start Completed Termination
4 Finished Wed Dec 14 19:51:56 2011 19:52:14 Success
5 Finished Wed Dec 14 19:52:14 2011 19:52:34 Success
6 Finished Wed Dec 14 19:52:14 2011 19:52:36 Success
7 Finished Wed Dec 14 19:52:14 2011 19:53:00 Success
8 Running Wed Dec 14 19:52:34 2011
9 Running Wed Dec 14 19:52:36 2011
10 Queued
11 Queued
12 Queued
13 Queued
Queued : 4, Running : 2, Aborted : 0, Failed : 0, Missing Result : 0, Finished : 4
Running
Free space : 13.4 GB
VWF Copyright © 1984 - 2011 SILVACO, Inc.

Figure 3-63 Job status – Jobs pane

You can open the Describe dialog by right-clicking on any of the bottom nodes in the tree view (see Figure 3-64). This dialog presents information around a single simulation job. The bottom most pane of the dialog allows you to select between the `Standard Output` and `Standard Error` streams of the simulator. The top left pane displays the name of the node and its split variables. The top right pane shows all files, which were generated during the simulation run. These can be structure files (`.STR`), log-files containing curves (`.LOG`), or any other generated file. In this part, you can also view (but not edit) the deck as given to the simulator. Double-clicking on any of the files will open the associated viewer. For example, double-clicking on a `.STR` file will open TonyPlot 3D.

Note: Files are only available once the simulation has been finished. This pane will be empty for any job that has not run yet.

Note: Every process in UNIX/Windows has assigned a standard output (`stdout`) and a standard error (`stderr`) stream. These streams are used to print low-level system information, such as debugging output or status information about simulator internals. You are not normally concerned with this information unless errors occur or unexpected results are obtained from a simulation.

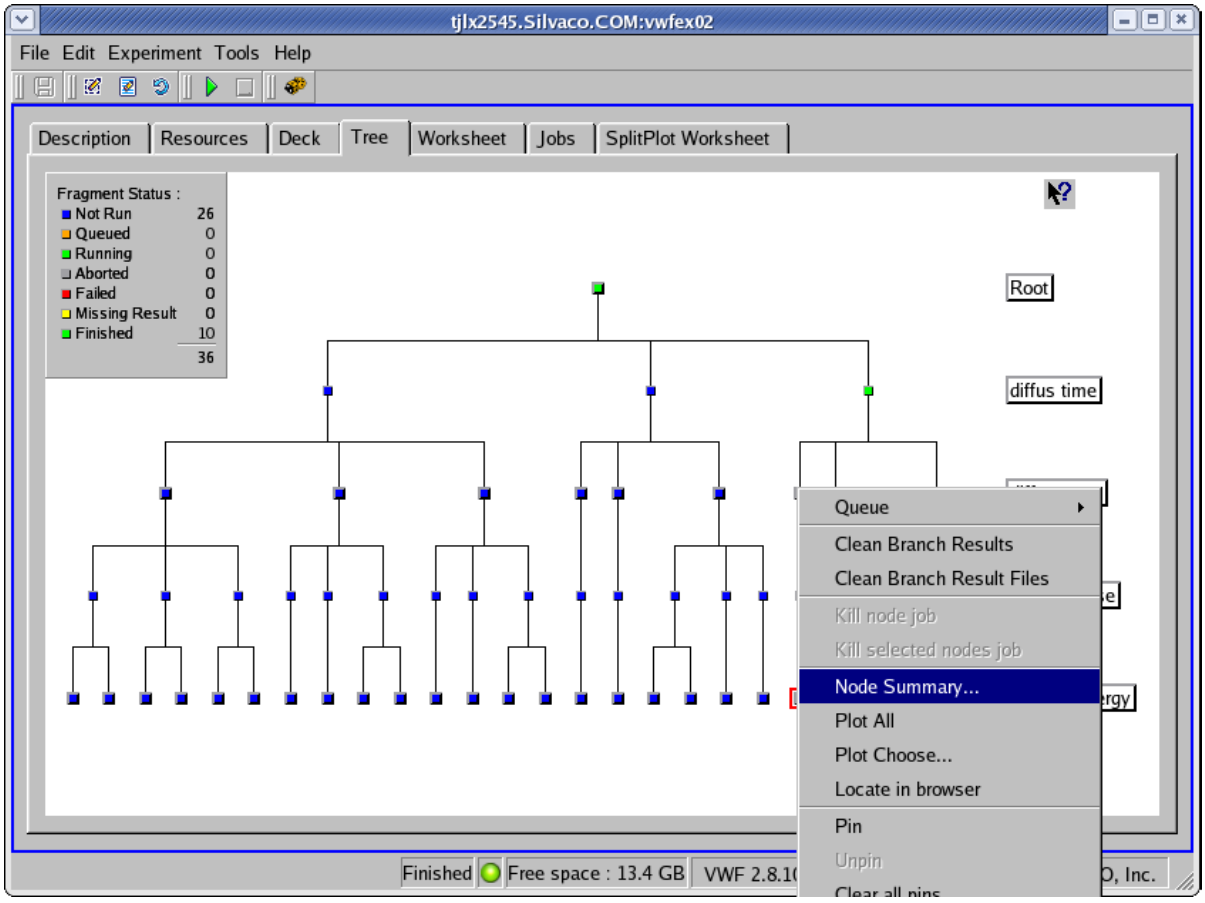


Figure 3-64 Node Summary menu entry

Figure 3-65 depicts an alternative way of getting the data associated with a node. Instead of using the tree tab of an opened experiment, you can use the experiment browser to directly navigate to any given node of the experiment. To use this feature, select an experiment in the left pane of the browser. The icon of the experiment will change and a “+” sign will be added. Upon clicking on the +, a sub-tree will open and present the view as shown in Figure 3-65. Note that the breadcrumbs view also changes to contain the path to the selected node.

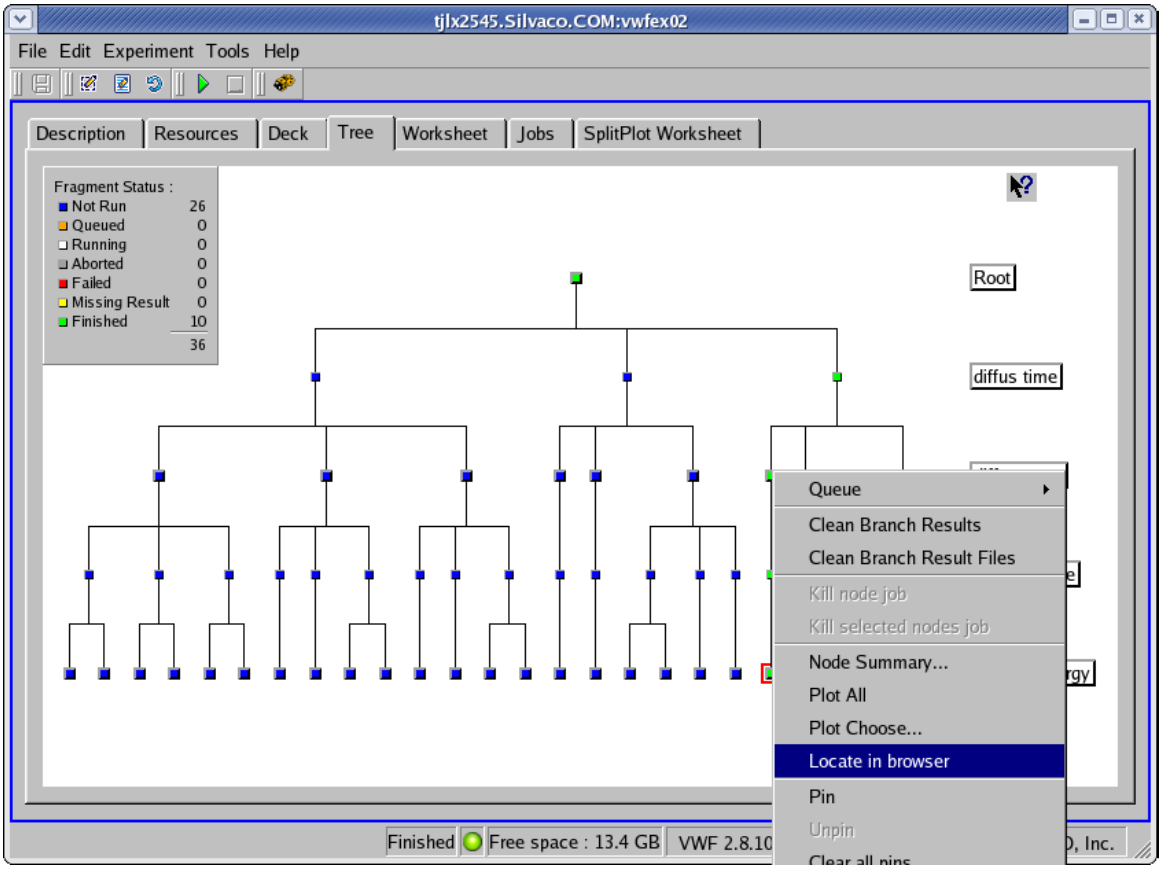


Figure 3-65 Locate in VWF Browser

Figure 3-66 depicts the context sensitive menu, which opens at right-clicking an experiment in the left pane of the browser window. You can choose to expand all nodes in the view or to collapse all nodes. This can be useful for large experiments with many nodes.

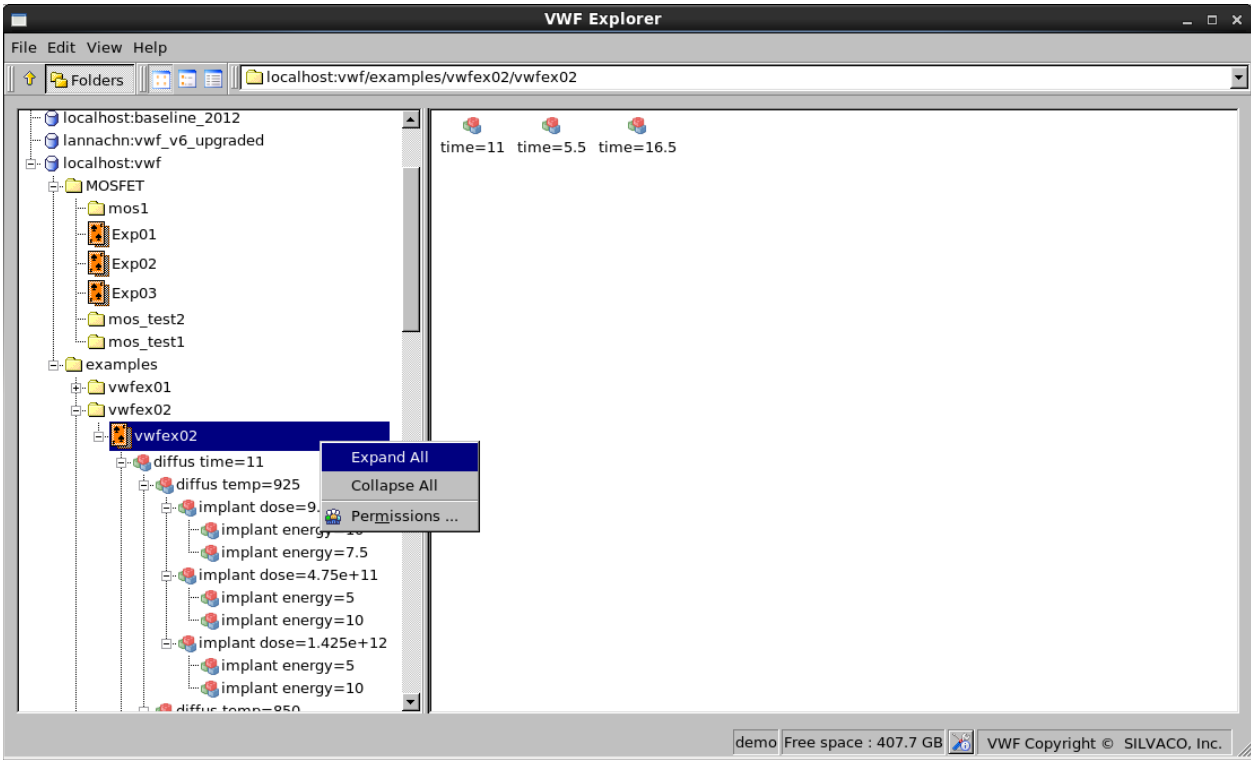


Figure 3-66 Expand and Collapse Experiment

VWF allows you to set so-called pins, which show up in the tree pane, the worksheet pane and the SplitPlot worksheet pane. This allows you to easily identify a particular node (worksheet cell) among the different views. Figure 3-67 shows the tree view with 3 pins set.

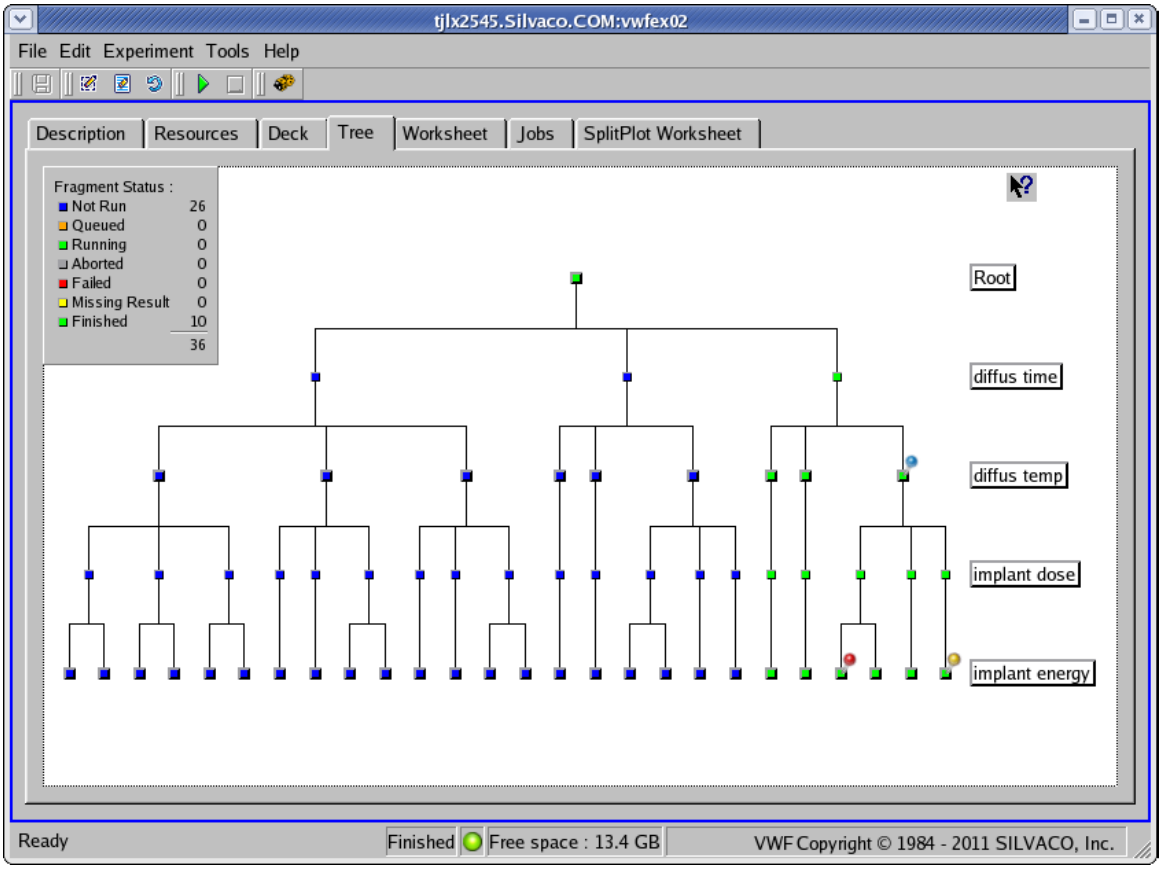


Figure 3-67 Tree with three pins, red, yellow, and blue

Figure 3-68 shows how a pin is set in the tree pane. You right-click on a node for which you would like to set a pin and navigate to the **Pin** entry of the menu. To remove a previously added pin, right-click on the node again and select **Unpin** from the menu. Figure 3-69 shows how the pin can be activated (**Pin**) or deactivated (**Unpin**) from the worksheet. **Clear all pins** will remove all previously defined pins (Figure 3-70).

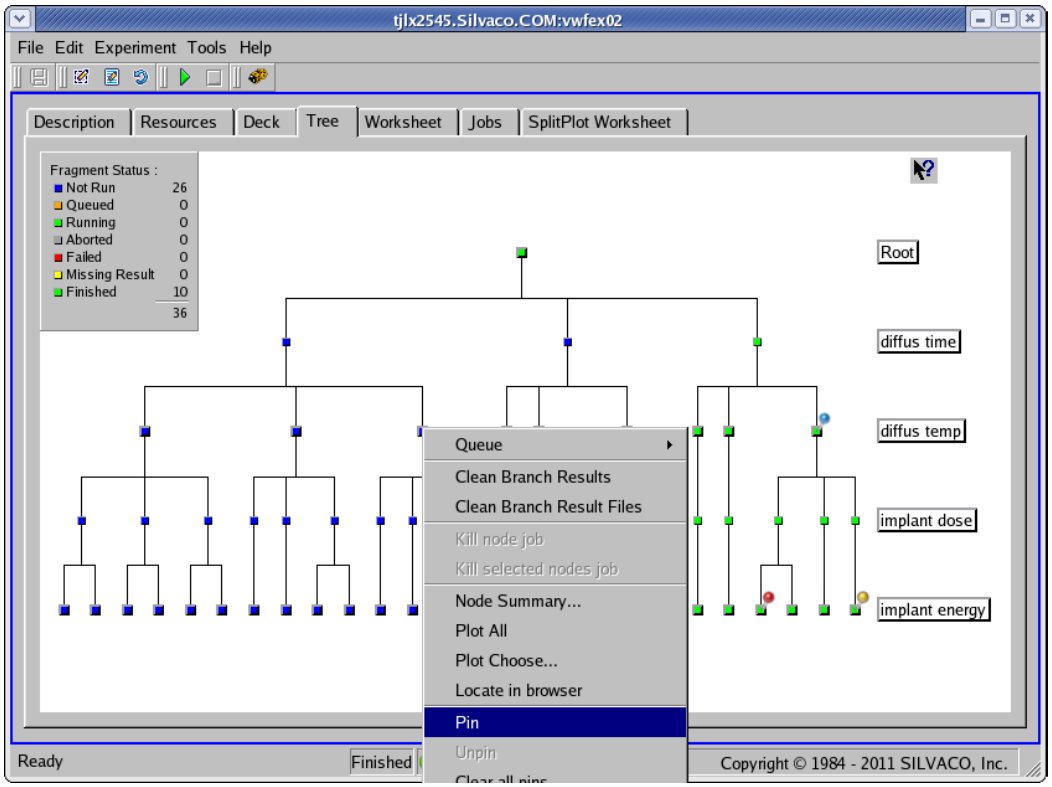


Figure 3-68 Setting a Pin in the Tree

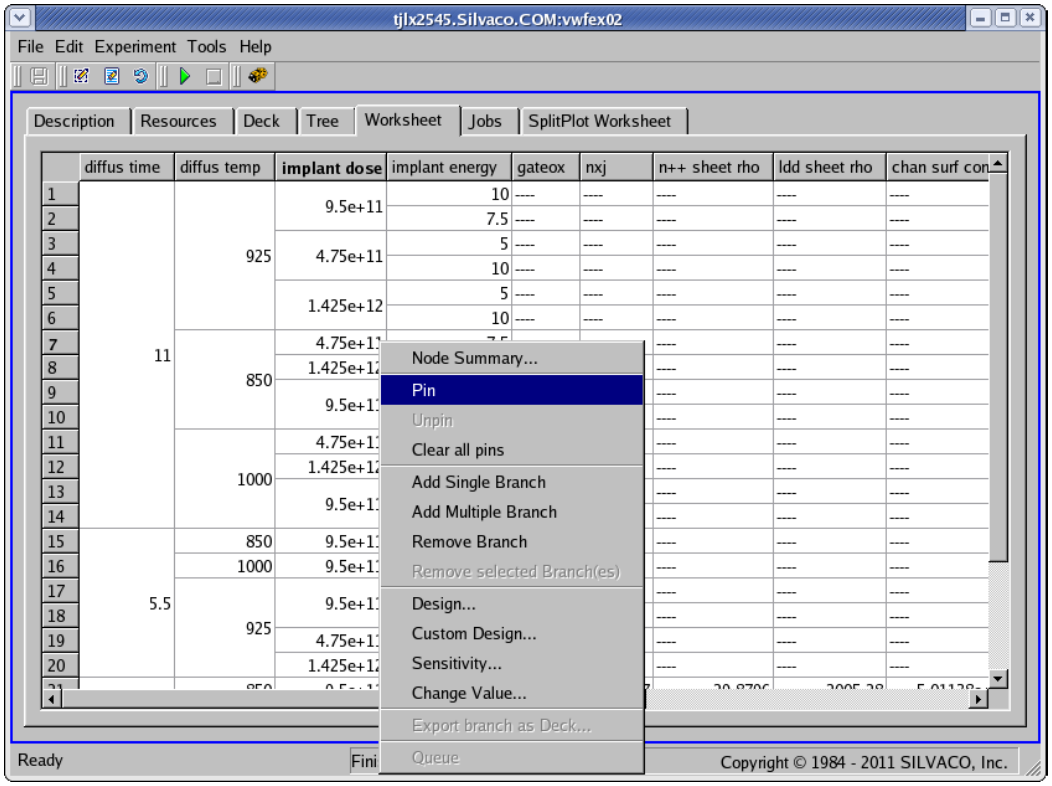


Figure 3-69 Setting a Pin from the Worksheet

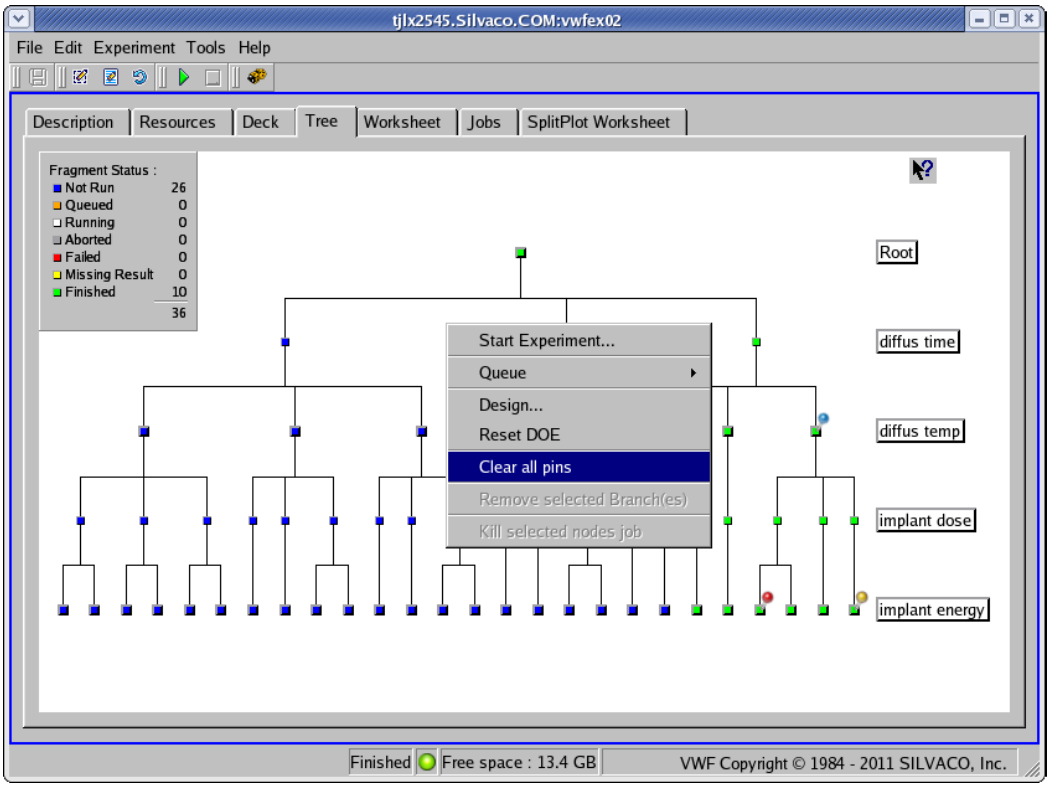


Figure 3-70 Clearing All Previously Set Pins

After all jobs of an experiment have been finished, you can view the extracted results in the worksheet or with an external tool like SPAYN (see Figure 3-71). It is possible that not all simulation jobs finished properly and give results. It is also possible that only a subset of results are available from some (or even all) of the jobs. If this is the case, you will have to inspect the runtime output of the simulation to further examine the cause of the problem. You will also have to tune deck parameters and rerun the failed simulations if you want the results.

Note: The worksheet is actually updated with extracted results whenever a job has finished.

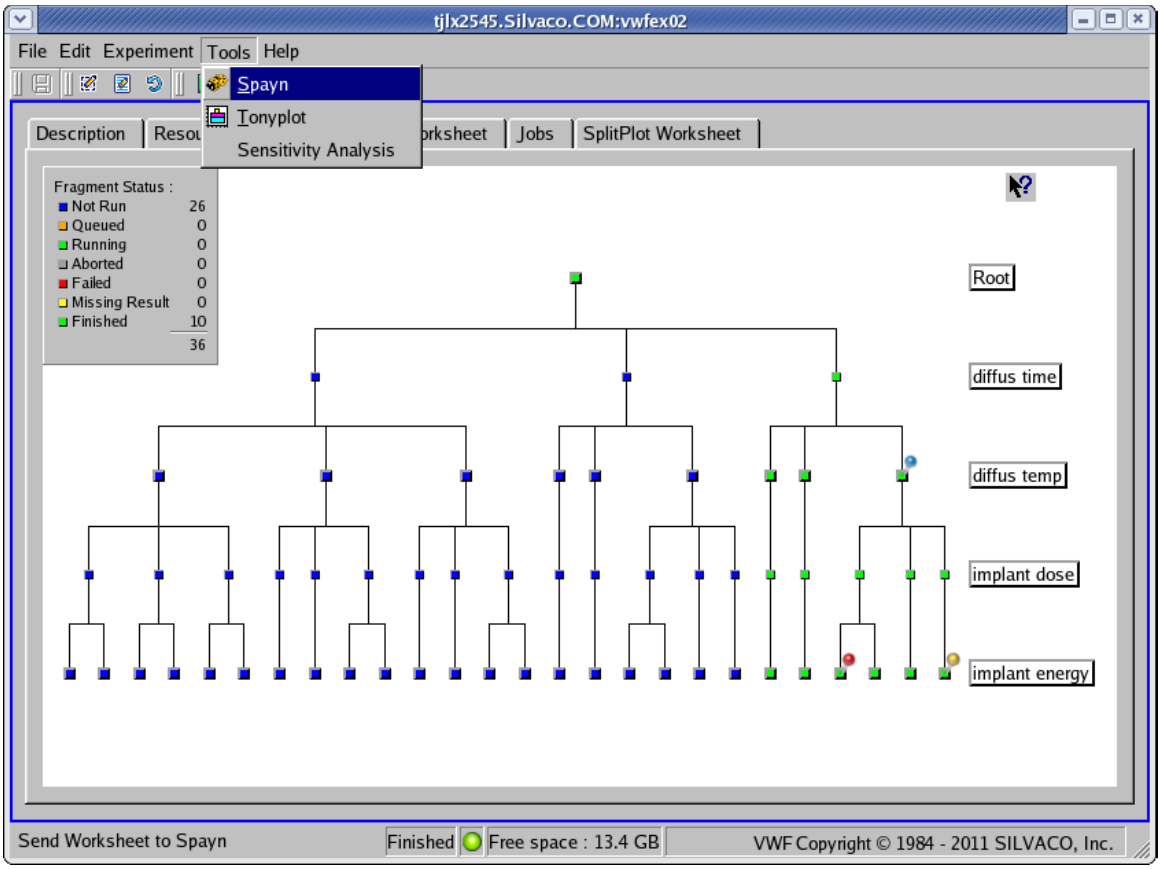


Figure 3-71 Send to Spayn Menu Entry

Figure 3-72 depicts the tab called **SplitPlot Worksheet**. This tab presents another view at the data with the main difference to the regular worksheet being that split variables are listed vertically rather than horizontally. This aids in selecting files for plotting with TonyPlot. The parameter combinations (splits) are displayed top to bottom with the root node at the top. No extracted parameters are displayed. When the experiment has finished, all files as generated during the simulation runs are displayed in the cells of this worksheet and are numbered uniquely by adding the row and column numbers of a given cell to the file name. You can select multiple files by holding down the Ctrl key and using your left mouse button. When satisfied with the selection, right-click in the **SplitPlot Worksheet** and select to either **Plot→Plot in Single TonyPlot window** or **Plot→Plot in separate TonyPlot windows**. Depending on your choice, either a single TonyPlot window will open and all files will be loaded into it or one TonyPlot window will open for every file you selected.

The name of the file will be used as the title in the TonyPlot display, so that you can easily relate a given plot to the cell in the **SplitPlot Worksheet** and the parameter combination, which has lead to the creation of that file.

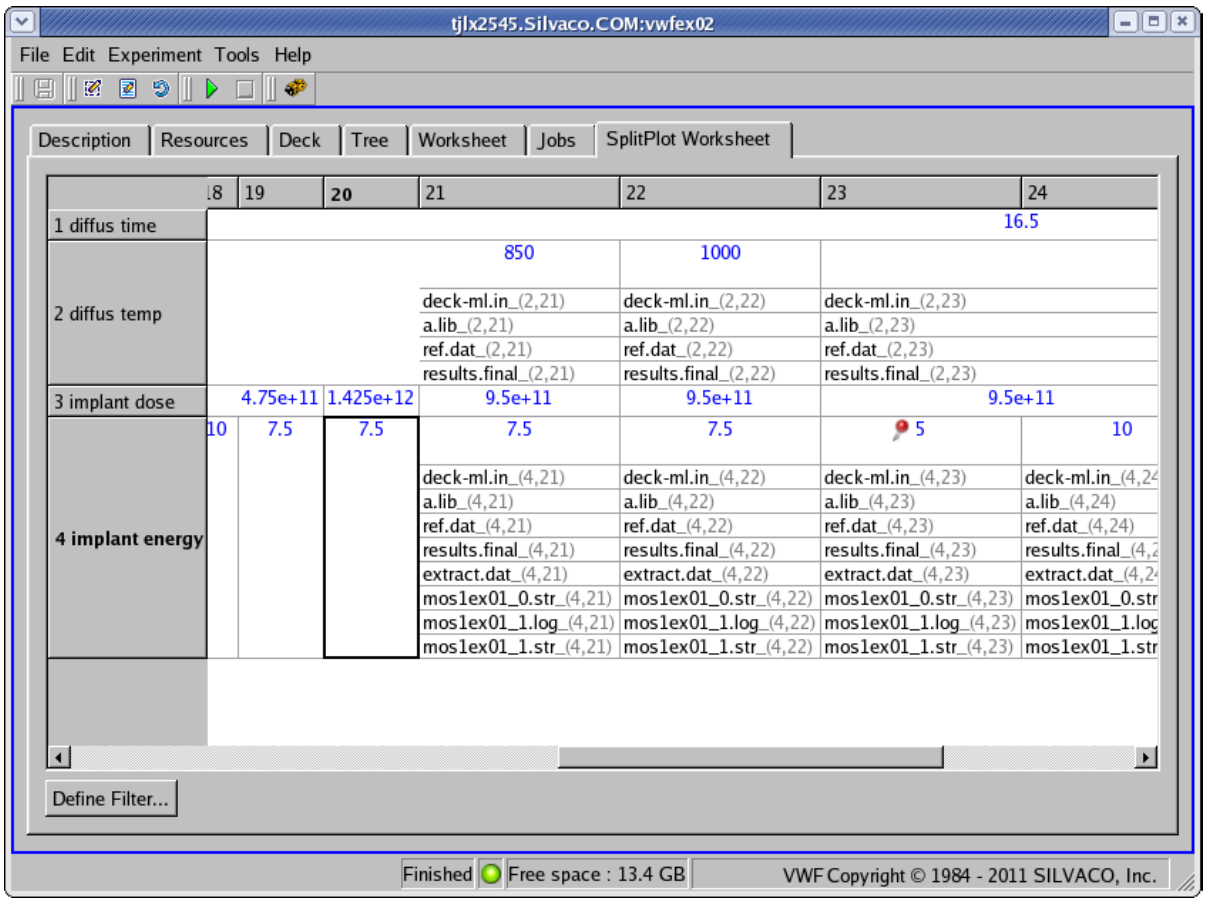


Figure 3-72 Populated SplitPlot Worksheet

For large sets of result files, you can use the filter at the left bottom of the **SplitPlot Worksheet** to reduce the number of displayed files before starting with your selection. For instance, you can decide to hide all `.str` files but show all `.dat` files. Figure 3-73 shows the dialog, which opens upon clicking on the **Define Filter** button.

Figure 3-73 SplitPlot Filter

Figure 3-74 shows the remaining entries after `.str` and `.log` files have been selected and the filter dialog has been closed using **OK**.

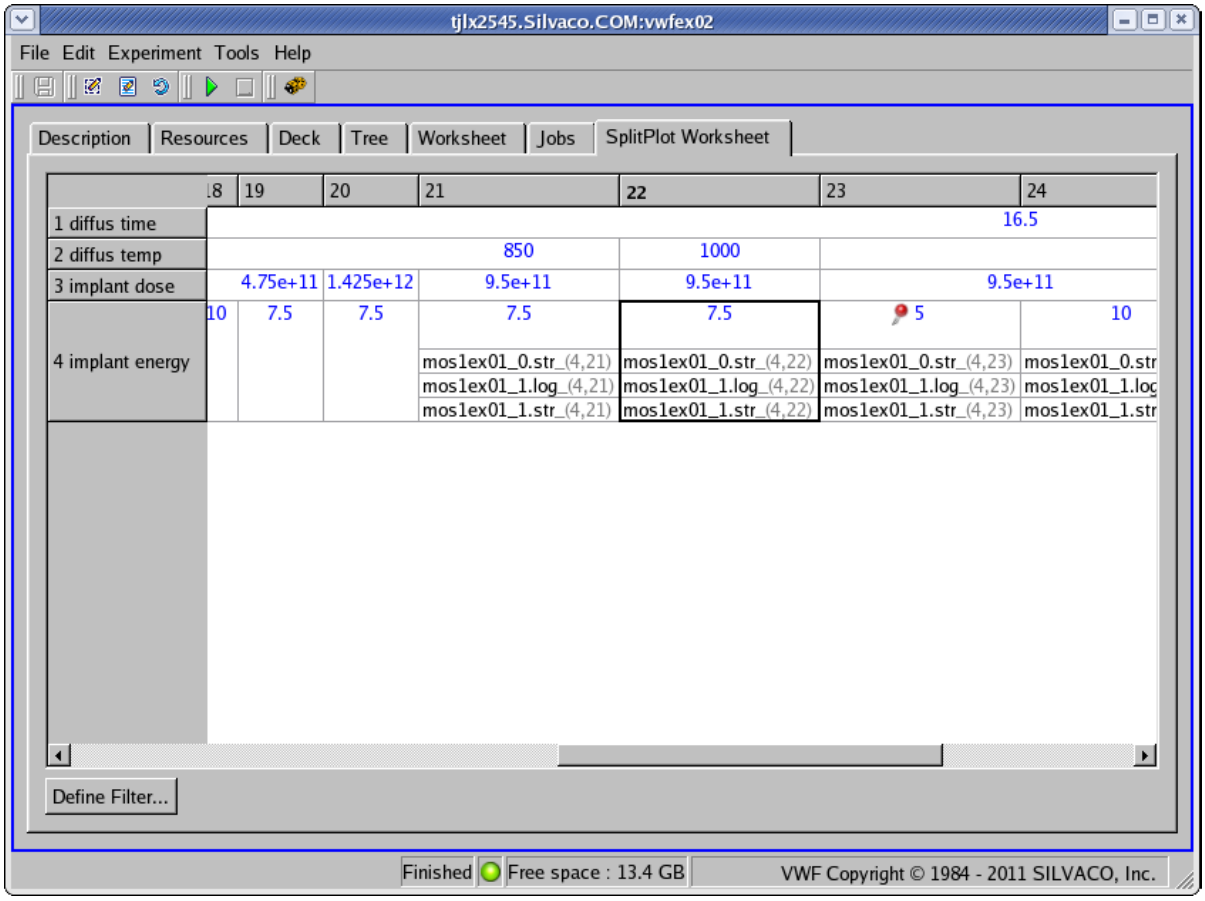

tjlx2545.Silvaco.COM:vwfex02
File Edit Experiment Tools Help
Description Resources Deck Tree Worksheet Jobs SplitPlot Worksheet
18 19 20 21 22 23 24
1 diffus time
16.5
2 diffus temp
850 1000
3 implant dose
4.75e+11 1.425e+12 9.5e+11 9.5e+11 9.5e+11
4 implant energy
10 7.5 7.5 7.5 7.5 5 10
mos1ex01_0.str_(4,21) mos1ex01_0.str_(4,22) mos1ex01_0.str_(4,23) mos1ex01_0.str
mos1ex01_1.log_(4,21) mos1ex01_1.log_(4,22) mos1ex01_1.log_(4,23) mos1ex01_1.log
mos1ex01_1.str_(4,21) mos1ex01_1.str_(4,22) mos1ex01_1.str_(4,23) mos1ex01_1.str
Define Filter...
Finished
Free space : 13.4 GB
VWF Copyright © 1984 - 2011 SILVACO, Inc.

Figure 3-74 Filtered Entries of SplitPlot Worksheet

Figure 3-75 shows two selected files and the menu, which opens upon right-clicking.

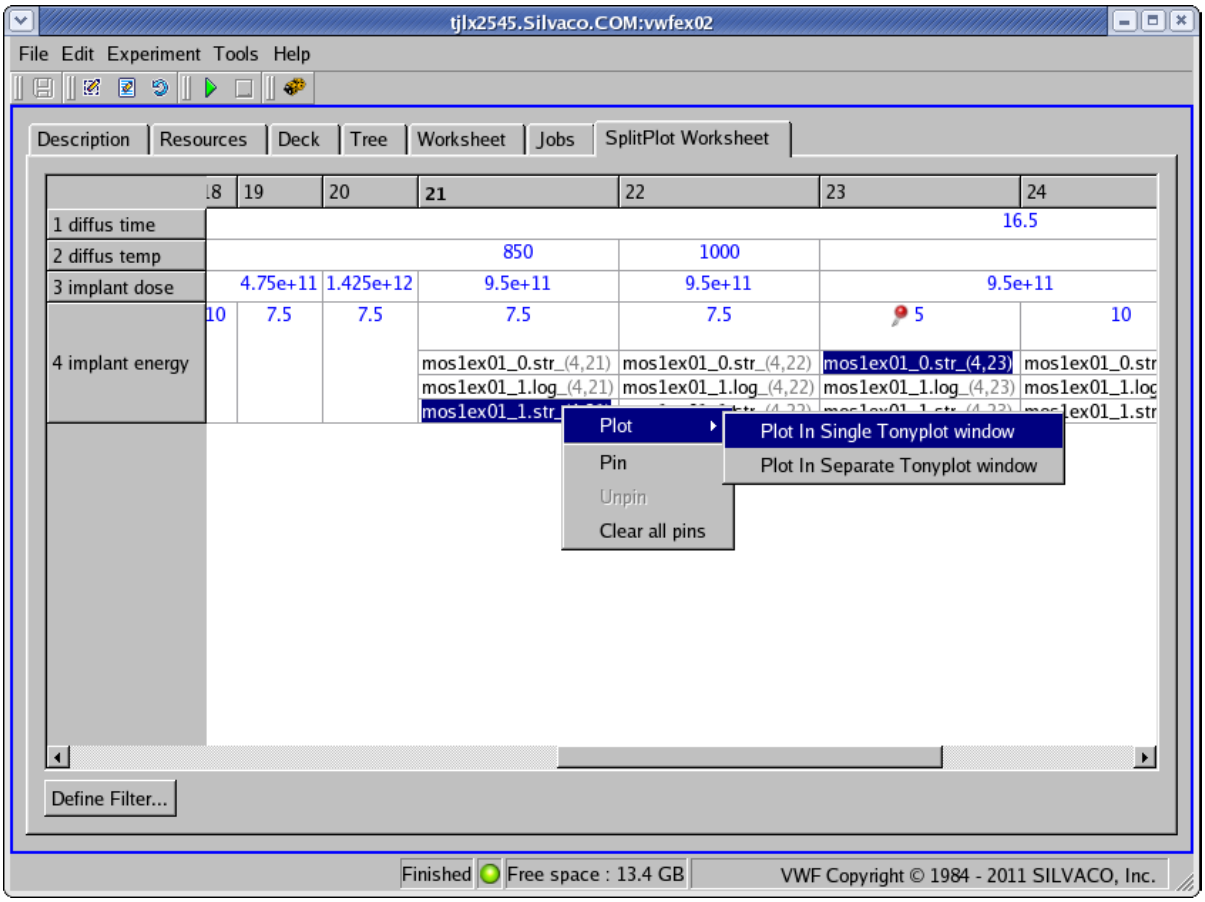


Figure 3-75 SplitPlot Worksheet with Selected Files

Figure 3-76 shows the started TonyPlot Window with the two selected files loaded. Please note the titles of the two displays, which identify the cells of the **SplitPlot Worksheet** (4.23 and 4.21).

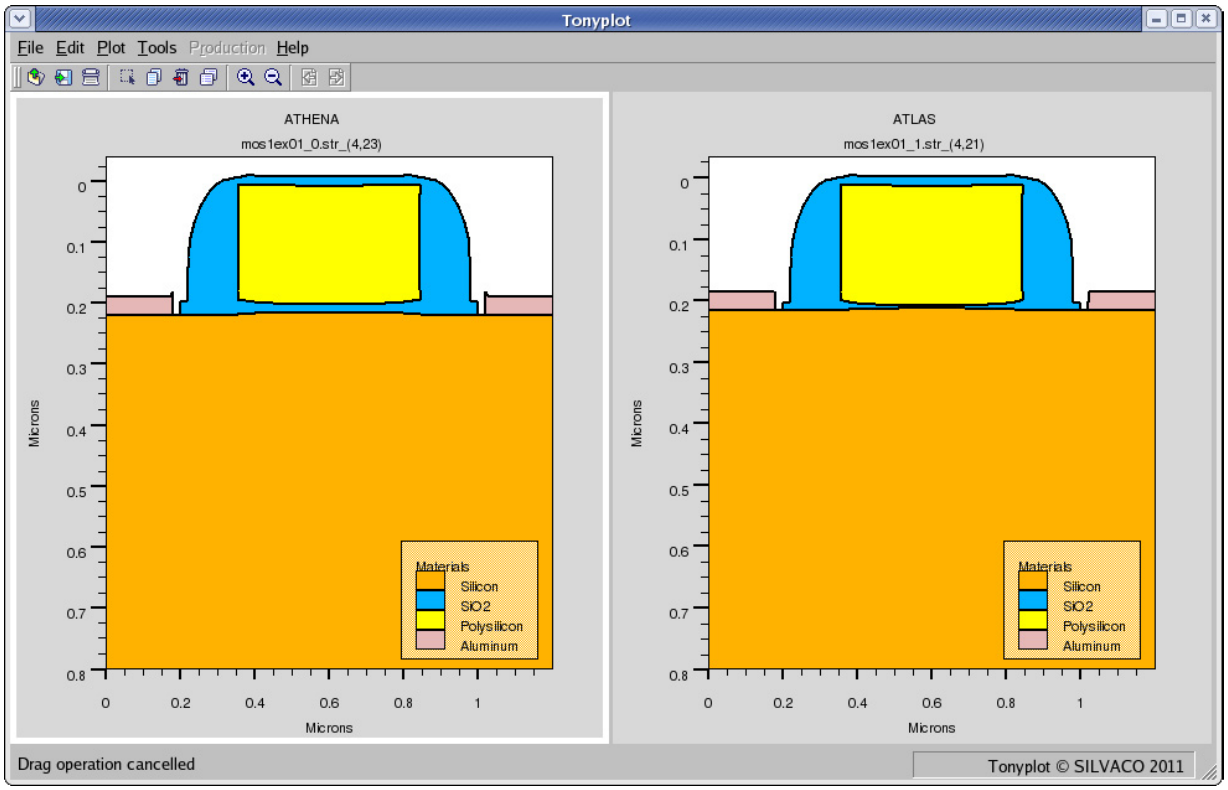


Figure 3-76 TonyPlot with files loaded from SplitPlot Worksheet

By selecting **Tools→Spayn**, the Send Worksheet To SPAYN dialog will appear (Figure 3-77). This dialog allows you to start SPAYN and create a new SPAYN worksheet. You can enter which parameters will be taken over into the SPAYN worksheet. SPAYN is started after clicking the **OK** button. Figure 3-78 shows the situation after SPAYN has been started and the SPAYN worksheet has been initialized.

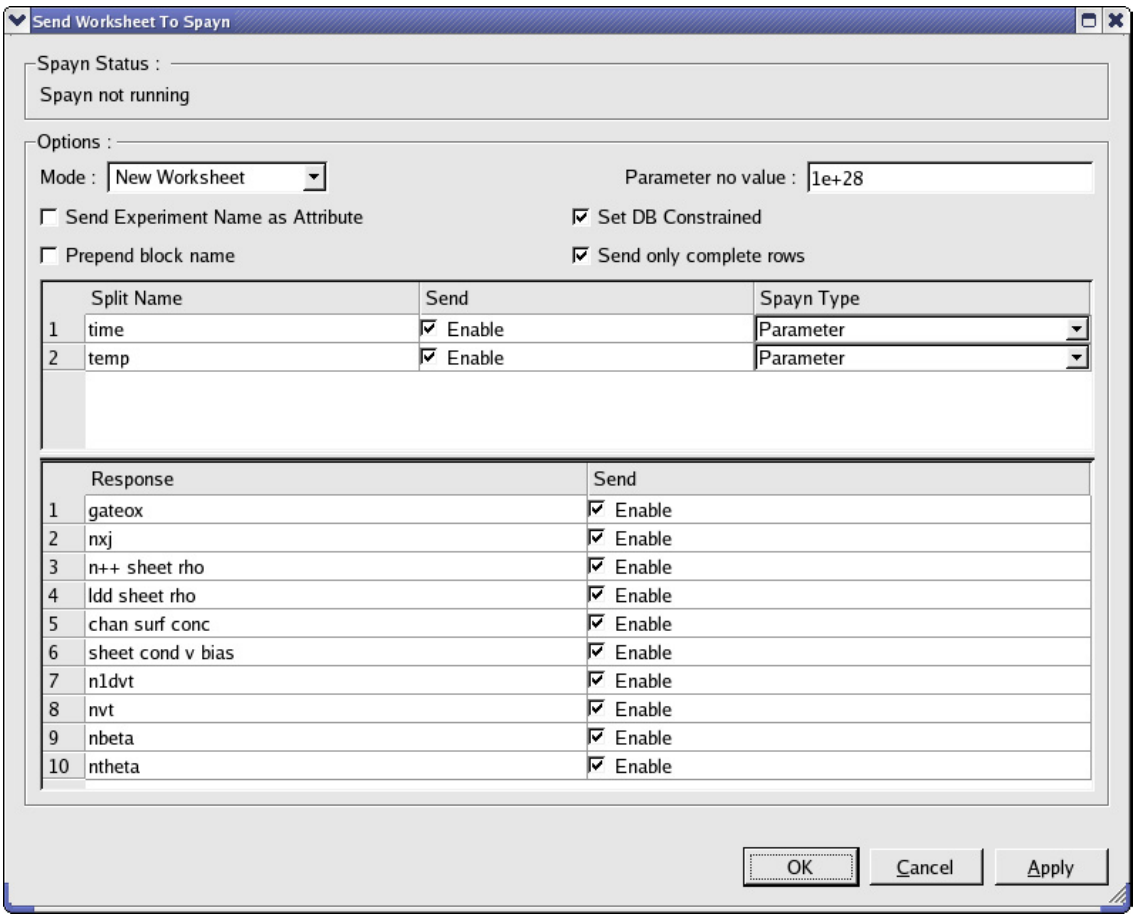


Figure 3-77 Send Worksheet To SPAYN dialog

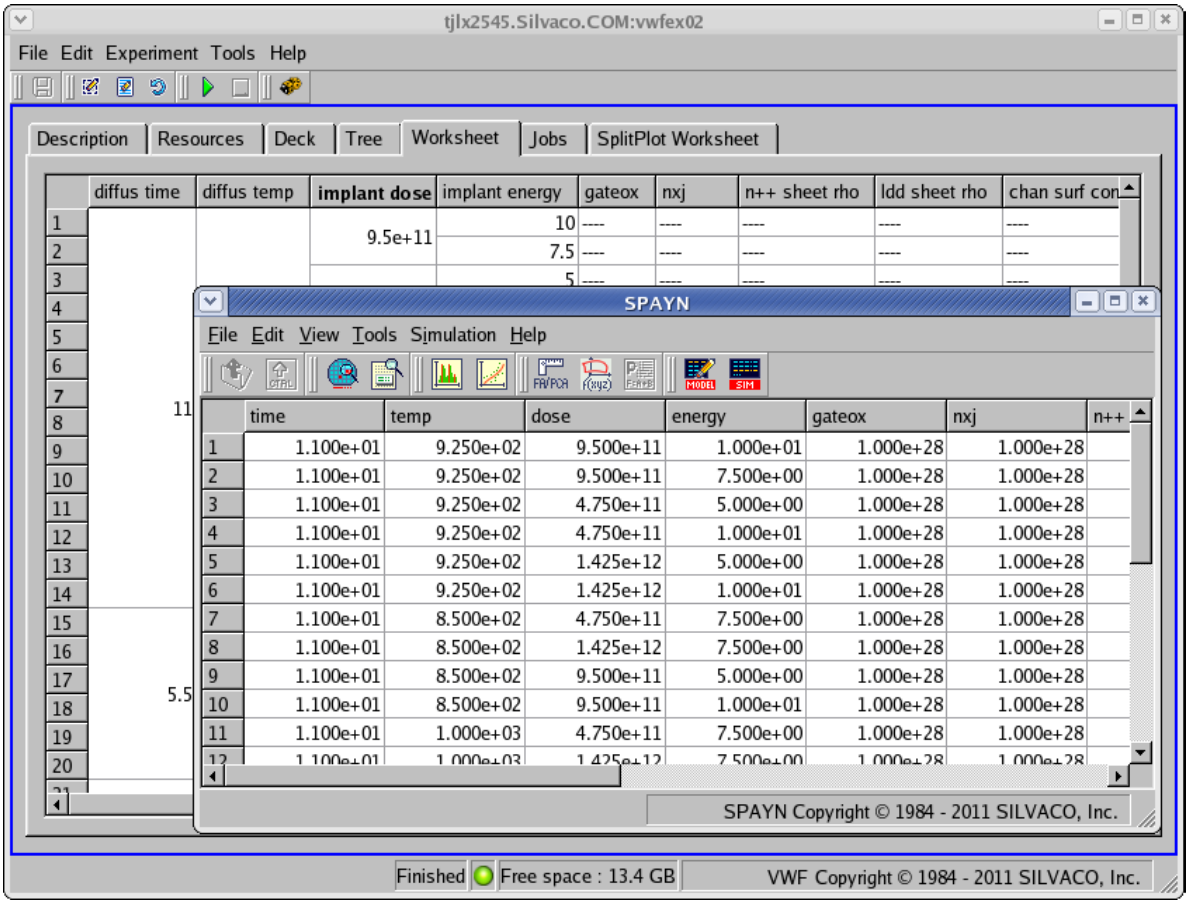


Figure 3-78 Worksheet Data Viewed in SPAYN

Chapter 4
Customizing VWF – Preferences Panel

VWF offers a wide range of customizable options. They are all found in the Preferences panel. When VWF is started you can open the preferences panel by selecting **Edit→Preferences** from the explorer window. Figure 4-1 shows the settings for the **Toolbars**. Clicking on **Customize** will open another window where you can change various settings related to the toolbars used in VWF.

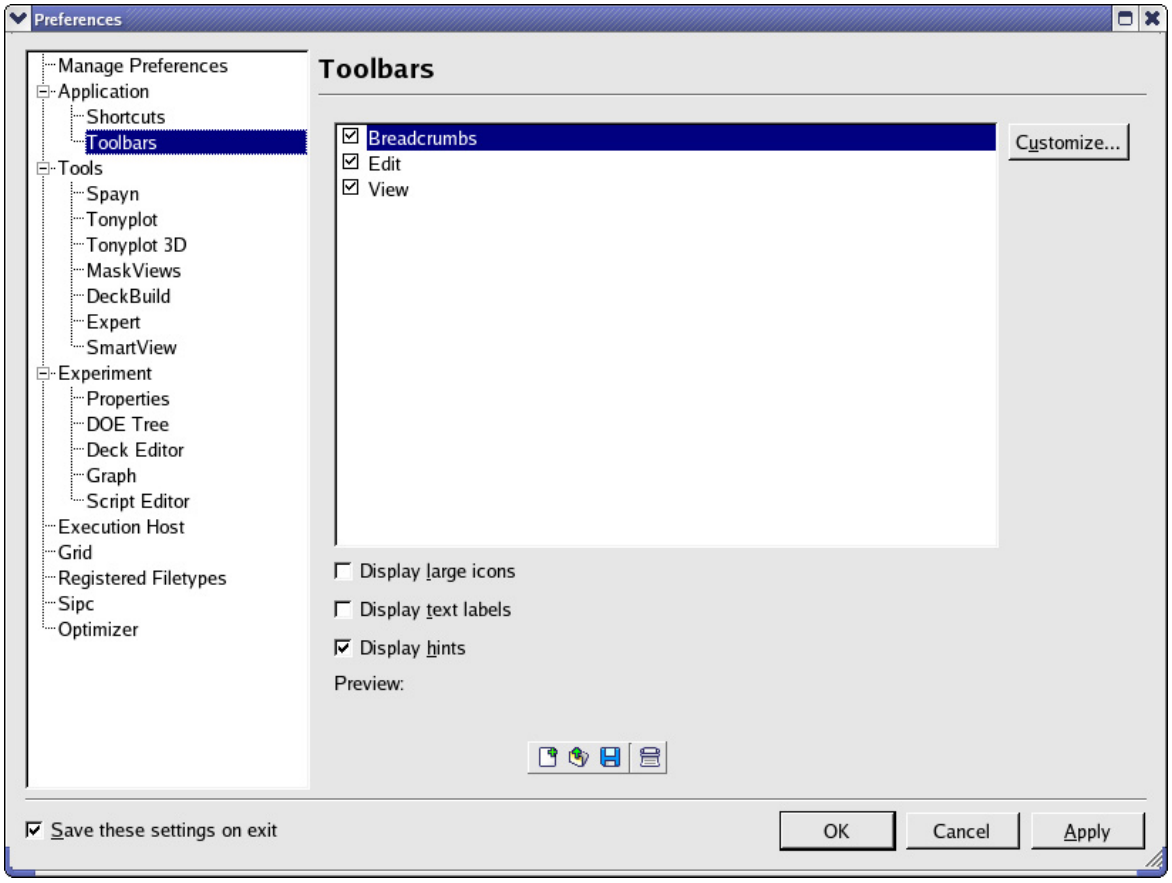


Figure 4-1 Preferences – Toolbars

Figure 4-2 displays the preferences settings for the shortcuts. Shortcuts can be selected for every menu operation in VWF.

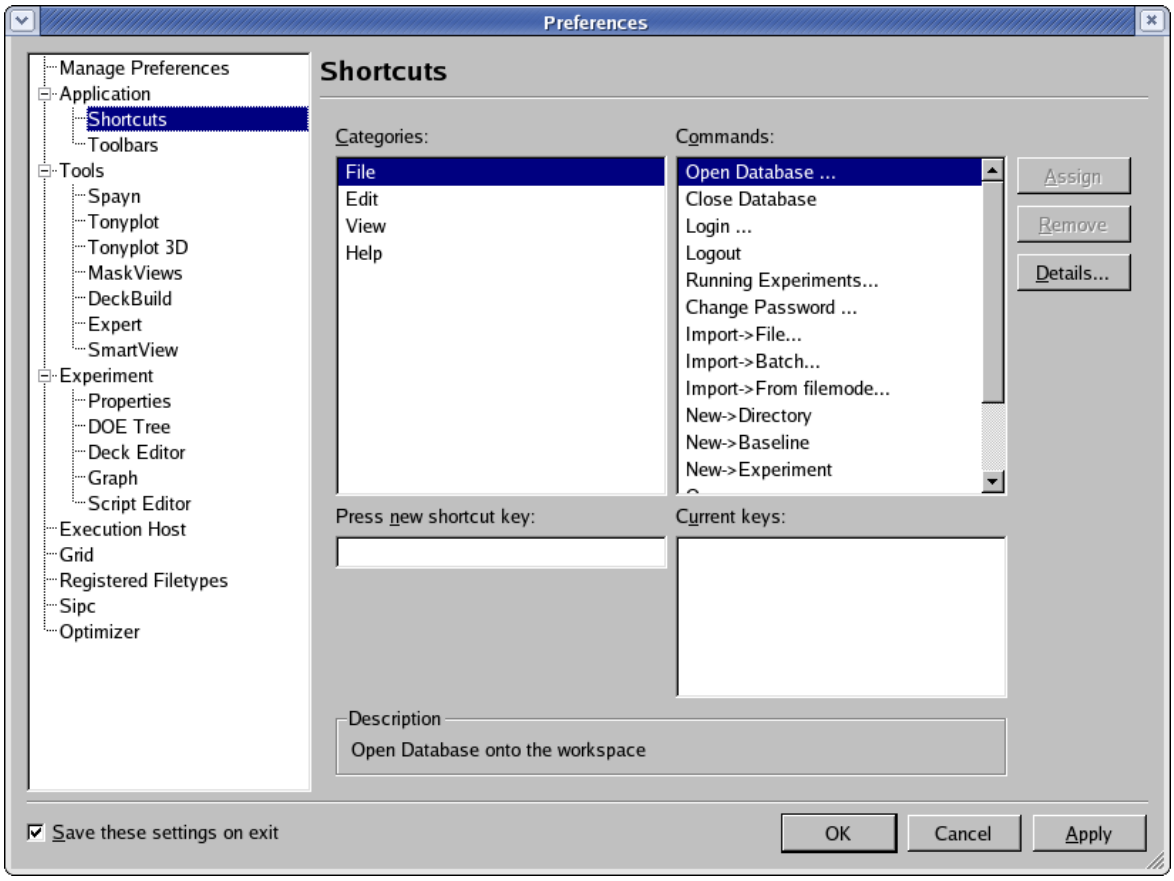


Figure 4-2 Preferences – Shortcuts

Figure 4-3 displays an entry from the tools section of the preferences panel. It is possible to select the versions being used for every tool and also the path where it was installed.

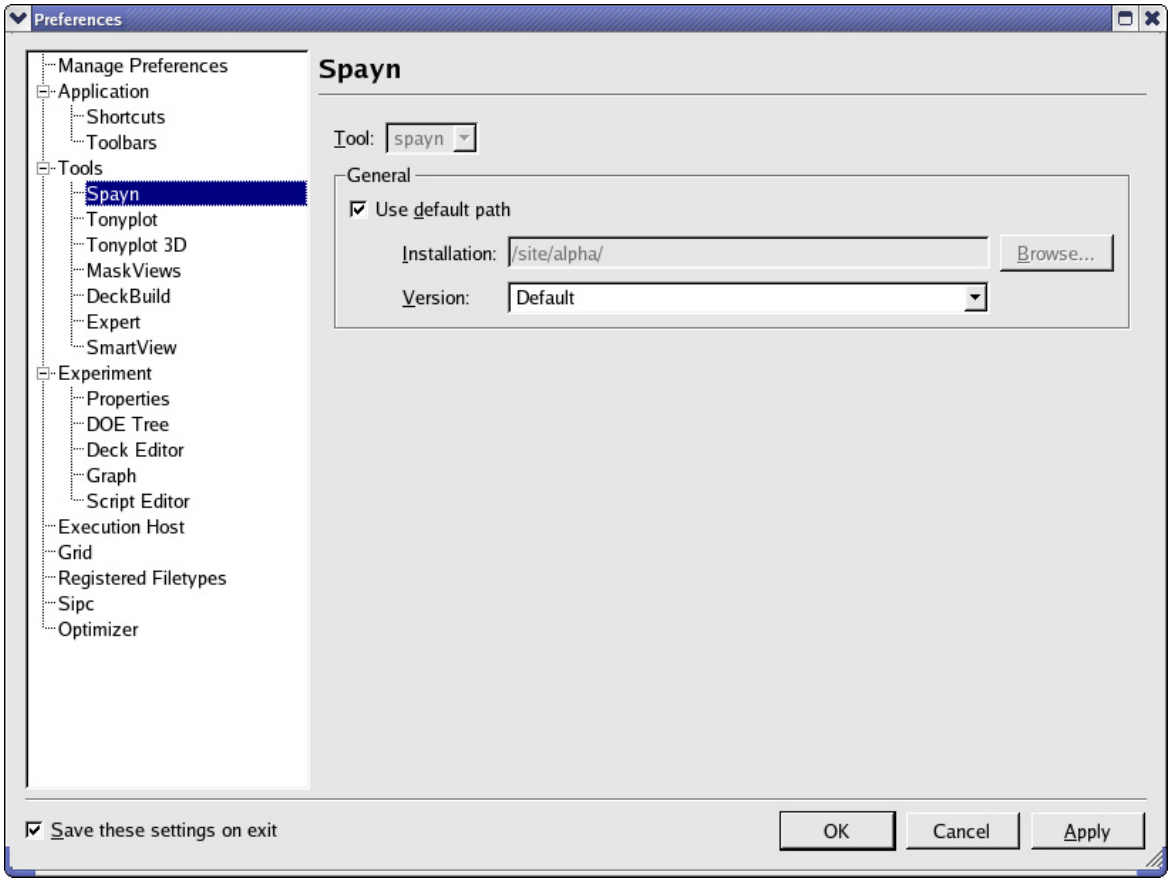


Figure 4-3 Preferences – Tools

Figure 4-4 displays the properties for experiments. At the top group of settings, you can select how the SmartView visualization tool is being started. In **Sipc** mode (default), only a single instance of SmartView is started and several files will be displayed in this single instance. When **Classical** is selected, then one SmartView instance is started per file.

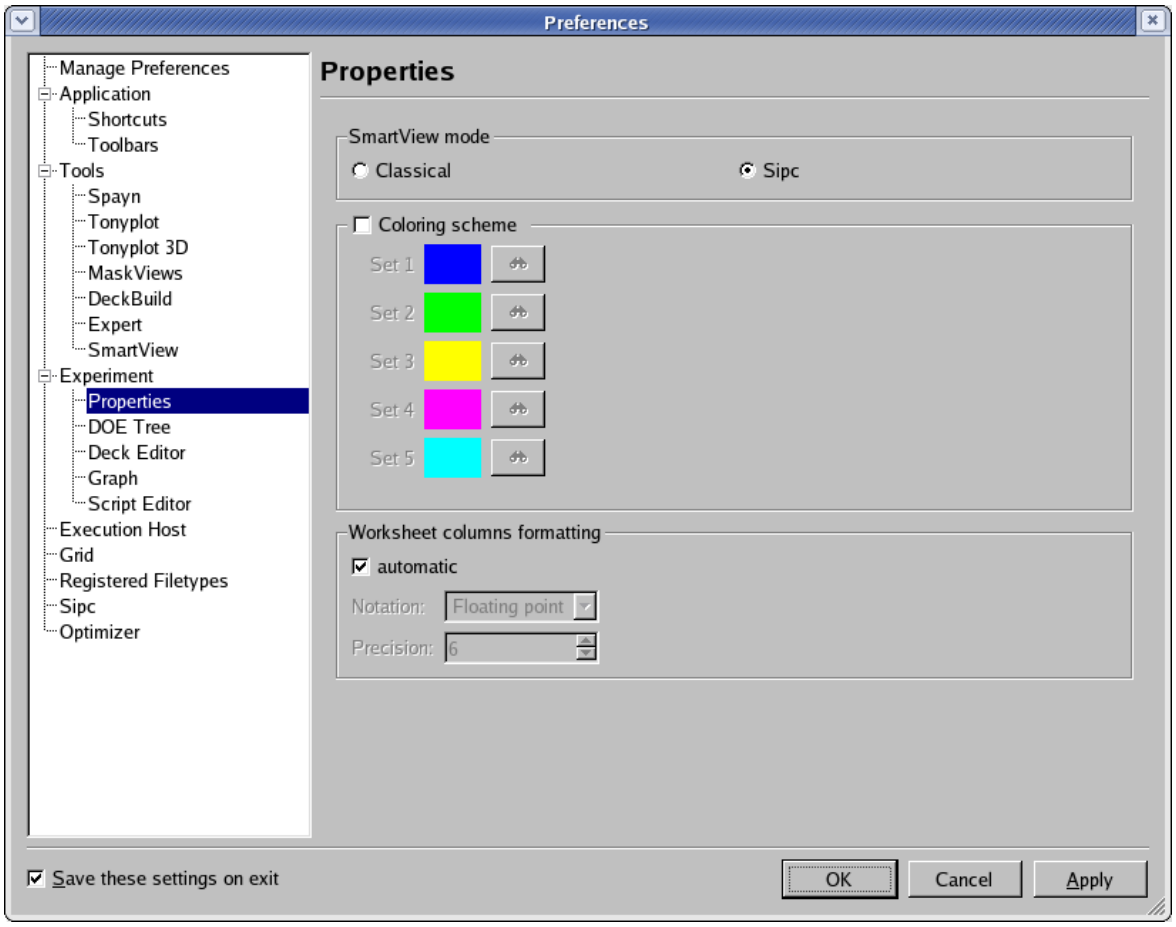


Figure 4-4 Preferences – Experiment Properties

The second group of settings allows you to enable and configure a coloring scheme. When enabled, all windows belonging to an experiment are grouped by adding a small frame around the window. Figure 4-5 depicts an example how an open experiment is framed using a green color.

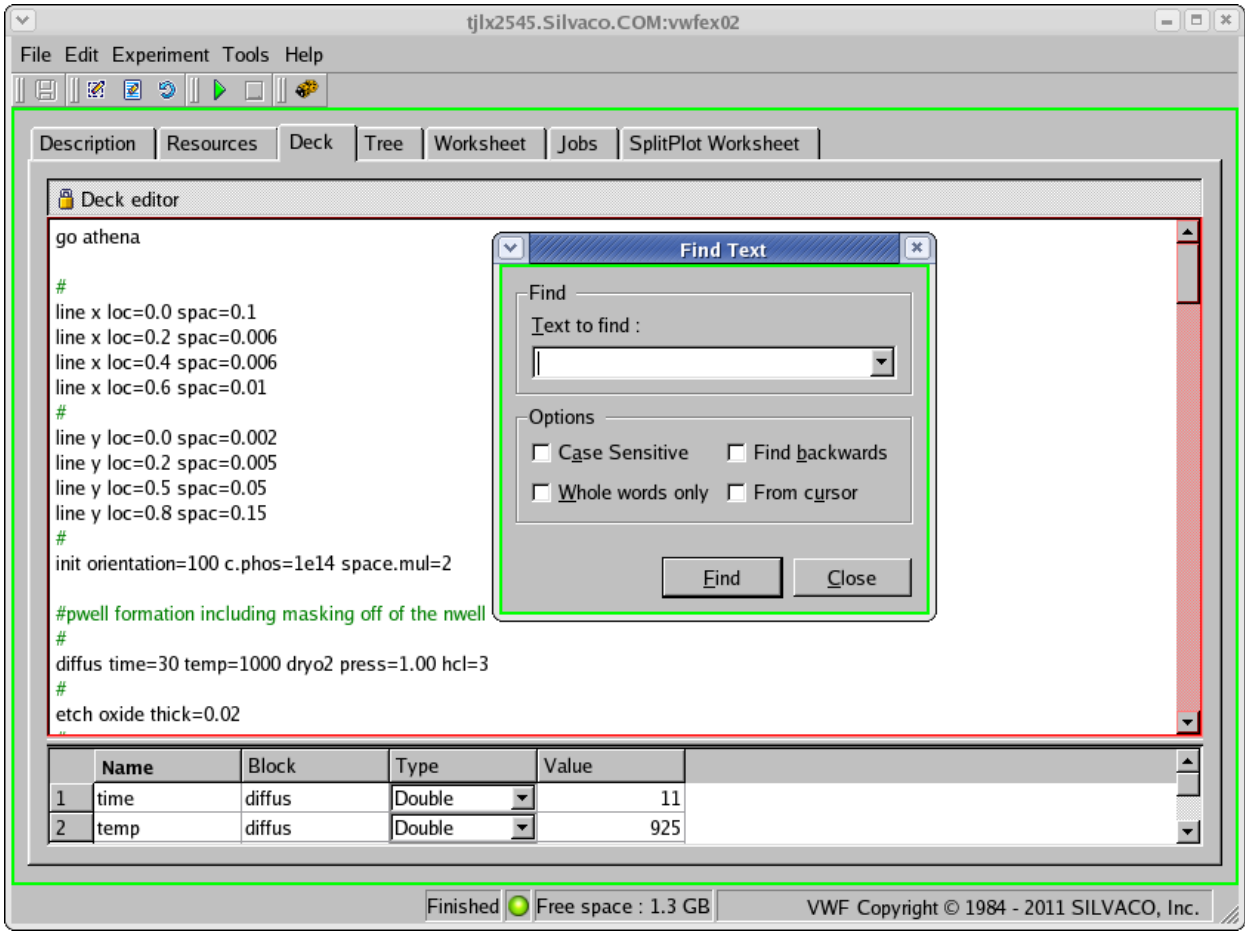


Figure 4-5 Coloring Scheme

Note that the format as defined in the preferences panel will generally be applied to all columns of the worksheet. If you do want to individually format the worksheet columns, however, you can do so directly in the worksheet. Any individual format defined on a column in the worksheet will override the settings as defined in preferences.

The third group of settings allows you to influence the way how data in columns are displayed. The default setting is automatic, which means that the format of a column depends on the contents. Larger numbers are displayed in scientific notation, whereas smaller numbers are displayed in fixed notation. Figure 4-6 shows how scientific notation with a precision of 5 significant digits can be chosen. Figures 4-7 and 4-8 display an example worksheet illustrating the difference between automatic and scientific notation.

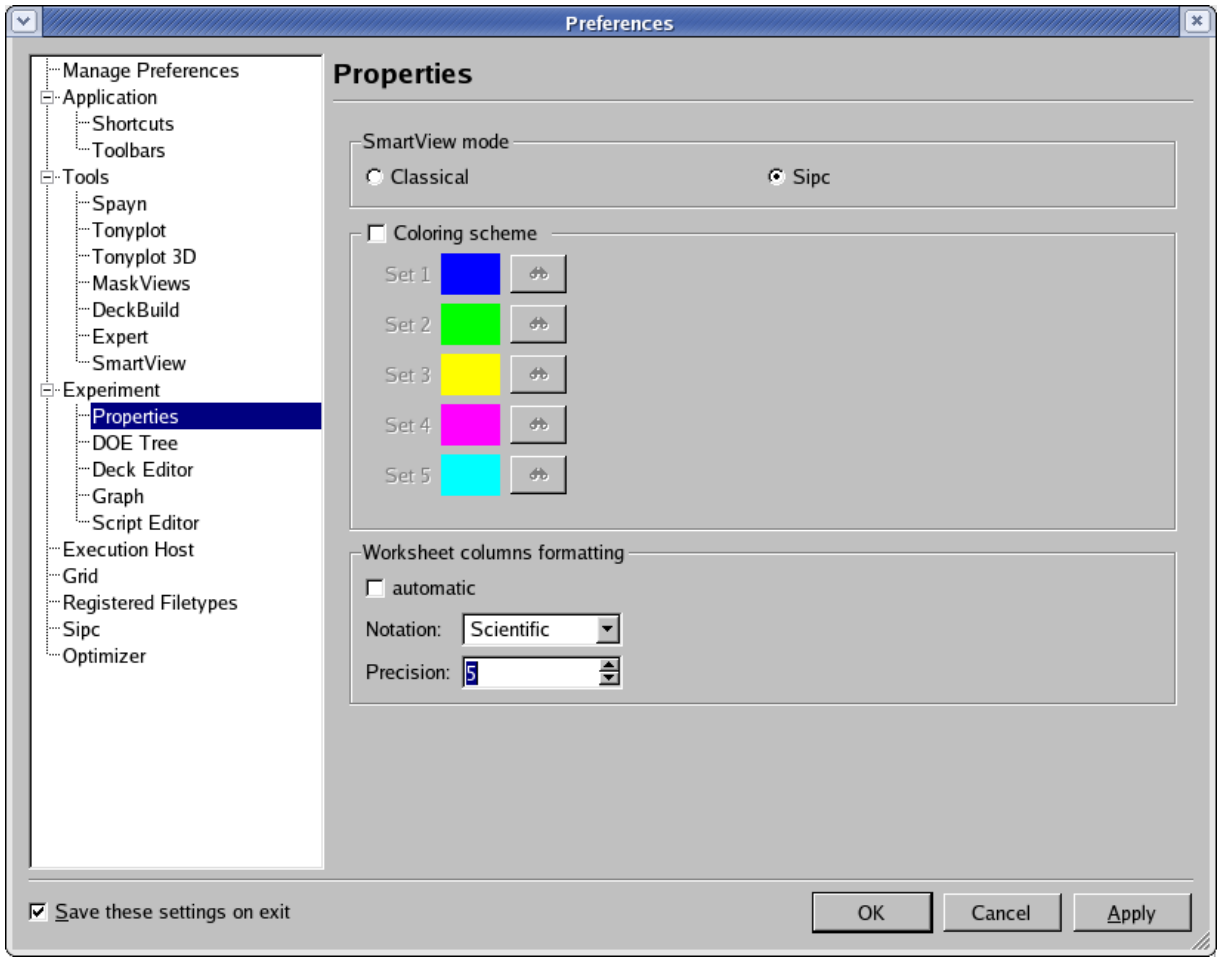
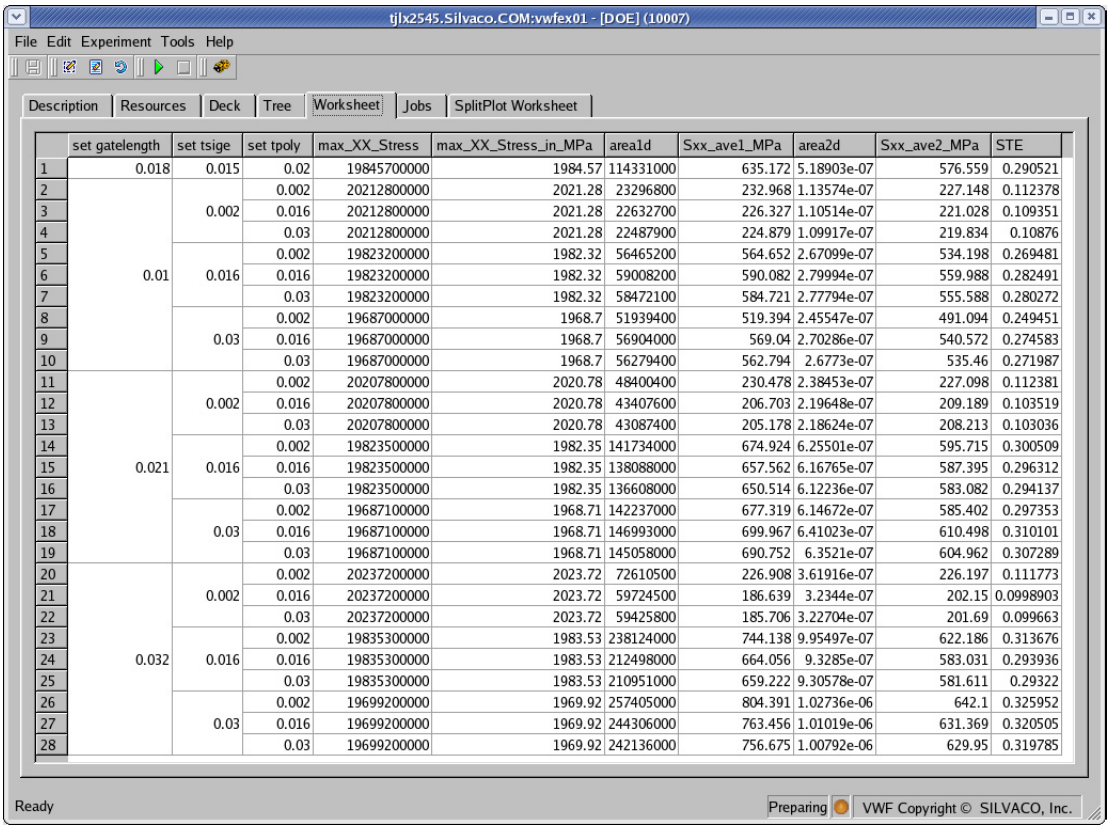
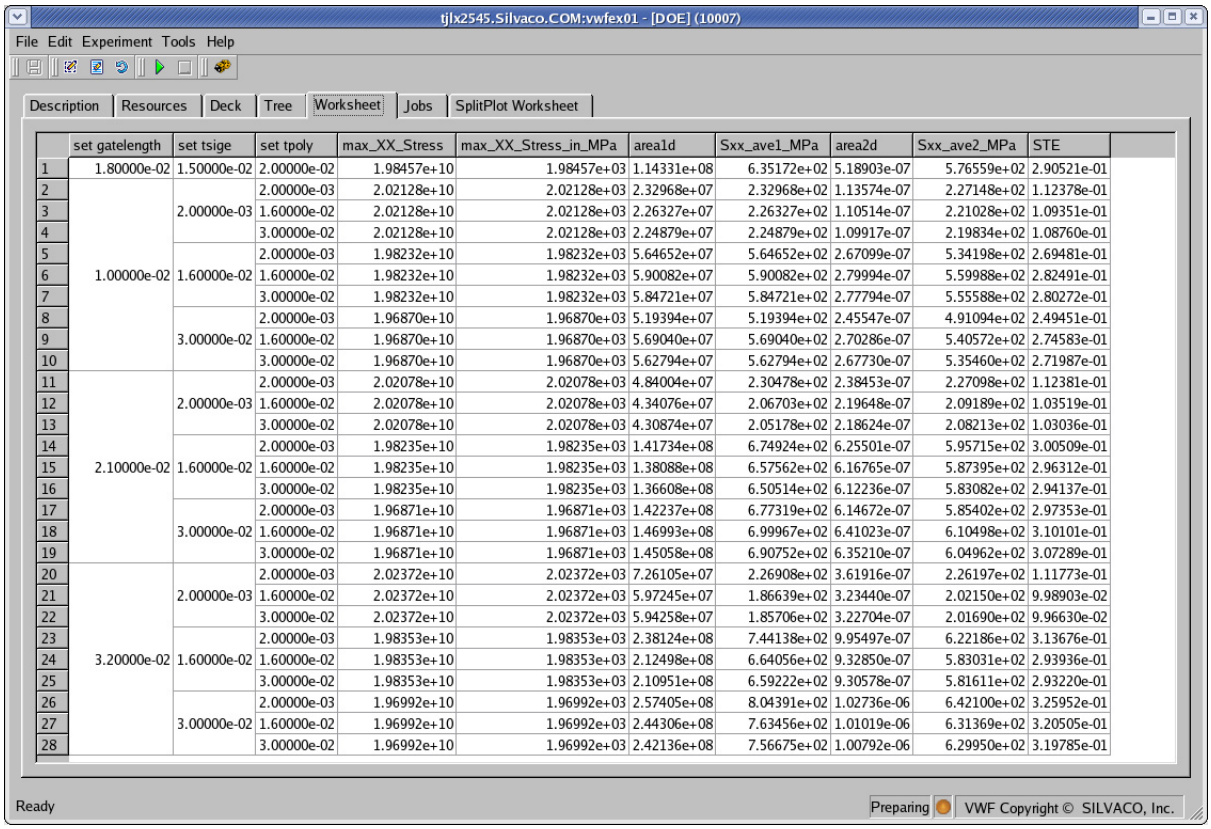


Figure 4-6 Worksheet Columns– Scientific Notation Selected


tjlx2545.Silvaco.COM:vwfex01 - [DOE] (10007)
File Edit Experiment Tools Help
Description Resources Deck Tree Worksheet Jobs SplitPlot Worksheet
Ready
Preparing
VWF Copyright © SILVACO, Inc.

	set gatelength	set tsige	set tpoly	max_XX_Stress	max_XX_Stress_in_MPa	area1d	Sxx_ave1_MPa	area2d	Sxx_ave2_MPa	STE
1	0.018	0.015	0.02	19845700000	1984.57	114331000	635.172	5.18903e-07	576.559	0.290521
2			0.002	20212800000	2021.28	23296800	232.968	1.13574e-07	227.148	0.112378
3		0.002	0.016	20212800000	2021.28	22632700	226.327	1.10514e-07	221.028	0.109351
4			0.03	20212800000	2021.28	22487900	224.879	1.09917e-07	219.834	0.10876
5			0.002	19823200000	1982.32	56465200	564.652	2.67099e-07	534.198	0.269481
6	0.01	0.016	0.016	19823200000	1982.32	59008200	590.082	2.79994e-07	559.988	0.282491
7			0.03	19823200000	1982.32	58472100	584.721	2.77794e-07	555.588	0.280272
8			0.002	19687000000	1968.7	51939400	519.394	2.45547e-07	491.094	0.249451
9		0.03	0.016	19687000000	1968.7	56904000	569.04	2.70286e-07	540.572	0.274583
10			0.03	19687000000	1968.7	56279400	562.794	2.6773e-07	535.46	0.271987
11			0.002	20207800000	2020.78	48400400	230.478	2.38453e-07	227.098	0.112381
12		0.002	0.016	20207800000	2020.78	43407600	206.703	2.19648e-07	209.189	0.103519
13			0.03	20207800000	2020.78	43087400	205.178	2.18624e-07	208.213	0.103036
14			0.002	19823500000	1982.35	141734000	674.924	6.25501e-07	595.715	0.300509
15	0.021	0.016	0.016	19823500000	1982.35	138088000	657.562	6.16765e-07	587.395	0.296312
16			0.03	19823500000	1982.35	136608000	650.514	6.12236e-07	583.082	0.294137
17			0.002	19687100000	1968.71	142237000	677.319	6.14672e-07	585.402	0.297353
18		0.03	0.016	19687100000	1968.71	146993000	699.967	6.41023e-07	610.498	0.310101
19			0.03	19687100000	1968.71	145058000	690.752	6.3521e-07	604.962	0.307289
20			0.002	20237200000	2023.72	72610500	226.908	3.61916e-07	226.197	0.111773
21		0.002	0.016	20237200000	2023.72	59724500	186.639	3.2344e-07	202.15	0.0998903
22			0.03	20237200000	2023.72	59425800	185.706	3.22704e-07	201.69	0.099663
23			0.002	19835300000	1983.53	238124000	744.138	9.95497e-07	622.186	0.313676
24	0.032	0.016	0.016	19835300000	1983.53	212498000	664.056	9.3285e-07	583.031	0.293936
25			0.03	19835300000	1983.53	210951000	659.222	9.30578e-07	581.611	0.29322
26			0.002	19699200000	1969.92	257405000	804.391	1.02736e-06	642.1	0.325952
27		0.03	0.016	19699200000	1969.92	244306000	763.456	1.01019e-06	631.369	0.320505
28			0.03	19699200000	1969.92	242136000	756.675	1.00792e-06	629.95	0.319785

Figure 4-7 Worksheet Columns– Automatic Setting


tjlx2545.Silvaco.COM:vwfex01 - [DOE] (10007)
File Edit Experiment Tools Help
Description Resources Deck Tree Worksheet Jobs SplitPlot Worksheet
Ready
Preparing
VWF Copyright © SILVACO, Inc.

	set gatelength	set tsige	set tpoly	max_XX_Stress	max_XX_Stress_in_MPa	area1d	Sxx_ave1_MPa	area2d	Sxx_ave2_MPa	STE
1	1.80000e-02	1.50000e-02	2.00000e-02	1.98457e+10	1.98457e+03	1.14331e+08	6.35172e+02	5.18903e-07	5.76559e+02	2.90521e-01
2			2.00000e-03	2.02128e+10	2.02128e+03	2.32968e+07	2.32968e+02	1.13574e-07	2.27148e+02	1.12378e-01
3		2.00000e-03	1.60000e-02	2.02128e+10	2.02128e+03	2.26327e+07	2.26327e+02	1.10514e-07	2.21028e+02	1.09351e-01
4			3.00000e-02	2.02128e+10	2.02128e+03	2.24879e+07	2.24879e+02	1.09917e-07	2.19834e+02	1.08760e-01
5			2.00000e-03	1.98232e+10	1.98232e+03	5.64652e+07	5.64652e+02	2.67099e-07	5.34198e+02	2.69481e-01
6	1.00000e-02	1.60000e-02	1.60000e-02	1.98232e+10	1.98232e+03	5.90082e+07	5.90082e+02	2.79994e-07	5.59988e+02	2.82491e-01
7			3.00000e-02	1.98232e+10	1.98232e+03	5.84721e+07	5.84721e+02	2.77794e-07	5.55588e+02	2.80272e-01
8			2.00000e-03	1.96870e+10	1.96870e+03	5.19394e+07	5.19394e+02	2.45547e-07	4.91094e+02	2.49451e-01
9		3.00000e-02	1.60000e-02	1.96870e+10	1.96870e+03	5.69040e+07	5.69040e+02	2.70286e-07	5.40572e+02	2.74583e-01
10			3.00000e-02	1.96870e+10	1.96870e+03	5.62794e+07	5.62794e+02	2.67730e-07	5.35460e+02	2.71987e-01
11			2.00000e-03	2.02078e+10	2.02078e+03	4.84004e+07	2.30478e+02	2.38453e-07	2.27098e+02	1.12381e-01
12		2.00000e-03	1.60000e-02	2.02078e+10	2.02078e+03	4.34076e+07	2.06703e+02	2.19648e-07	2.09189e+02	1.03519e-01
13			3.00000e-02	2.02078e+10	2.02078e+03	4.30874e+07	2.05178e+02	2.18624e-07	2.08213e+02	1.03036e-01
14			2.00000e-03	1.98235e+10	1.98235e+03	1.41734e+08	6.74924e+02	6.25501e-07	5.95715e+02	3.00509e-01
15	2.10000e-02	1.60000e-02	1.60000e-02	1.98235e+10	1.98235e+03	1.38088e+08	6.57562e+02	6.16765e-07	5.87395e+02	2.96312e-01
16			3.00000e-02	1.98235e+10	1.98235e+03	1.36608e+08	6.50514e+02	6.12236e-07	5.83082e+02	2.94137e-01
17			2.00000e-03	1.96871e+10	1.96871e+03	1.42237e+08	6.77319e+02	6.14672e-07	5.85402e+02	2.97353e-01
18		3.00000e-02	1.60000e-02	1.96871e+10	1.96871e+03	1.46993e+08	6.99967e+02	6.41023e-07	6.10498e+02	3.10101e-01
19			3.00000e-02	1.96871e+10	1.96871e+03	1.45058e+08	6.90752e+02	6.35210e-07	6.04962e+02	3.07289e-01
20			2.00000e-03	2.02372e+10	2.02372e+03	7.26105e+07	2.26908e+02	3.61916e-07	2.26197e+02	1.11773e-01
21		2.00000e-03	1.60000e-02	2.02372e+10	2.02372e+03	5.97245e+07	1.86639e+02	3.23440e-07	2.02150e+02	9.98903e-02
22			3.00000e-02	2.02372e+10	2.02372e+03	5.94258e+07	1.85706e+02	3.22704e-07	2.01690e+02	9.96630e-02
23			2.00000e-03	1.98353e+10	1.98353e+03	2.38124e+08	7.44138e+02	9.95497e-07	6.22186e+02	3.13676e-01
24	3.20000e-02	1.60000e-02	1.60000e-02	1.98353e+10	1.98353e+03	2.12498e+08	6.64056e+02	9.32850e-07	5.83031e+02	2.93936e-01
25			3.00000e-02	1.98353e+10	1.98353e+03	2.10951e+08	6.59222e+02	9.30578e-07	5.81611e+02	2.93220e-01
26			2.00000e-03	1.96992e+10	1.96992e+03	2.57405e+08	8.04391e+02	1.02736e-06	6.42100e+02	3.25952e-01
27		3.00000e-02	1.60000e-02	1.96992e+10	1.96992e+03	2.44306e+08	7.63456e+02	1.01019e-06	6.31369e+02	3.20505e-01
28			3.00000e-02	1.96992e+10	1.96992e+03	2.42136e+08	7.56675e+02	1.00792e-06	6.29950e+02	3.19785e-01

Figure 4-8 Worksheet Columns– Scientific Setting

Figure 4-9 displays the settings for the DOE tree. Colors for various components can be changed as well as the style for the connectors (line between the tree nodes) and the nodes.

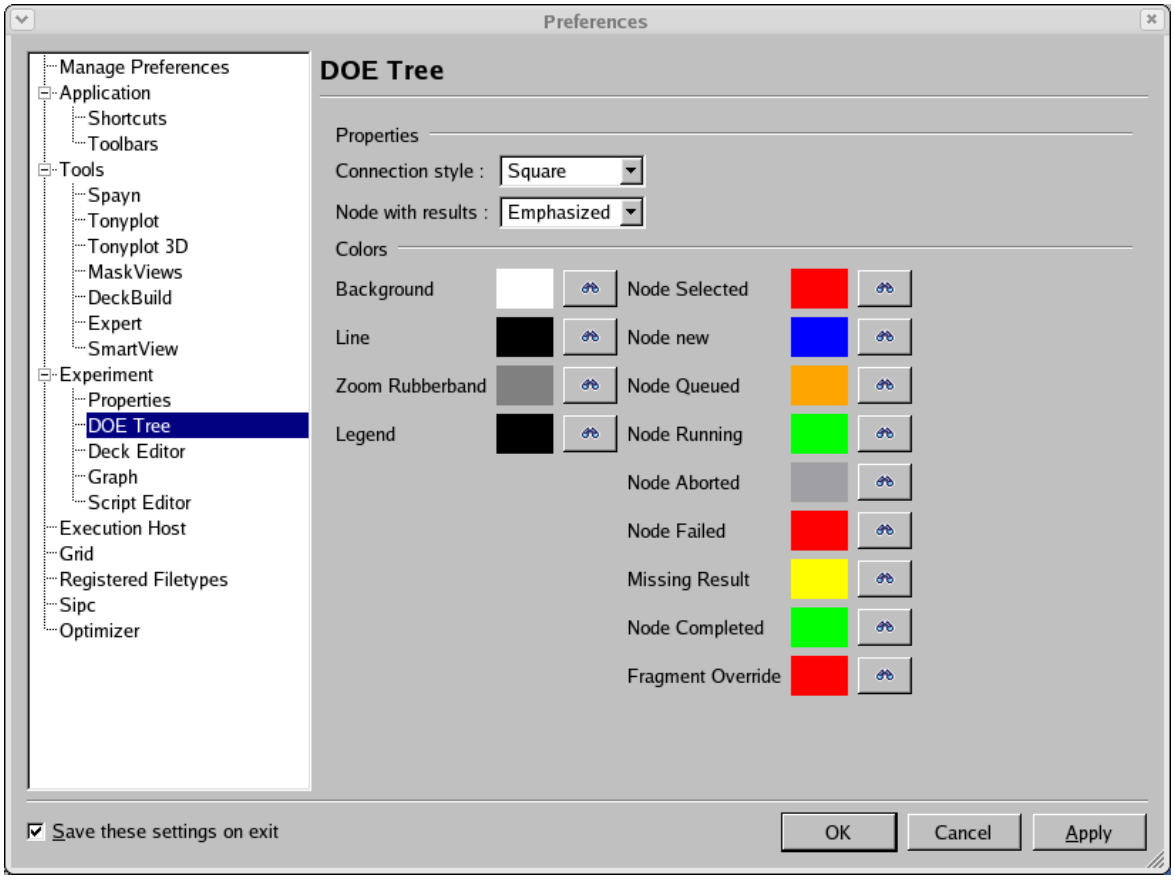


Figure 4-9 Preferences – DOE Tree

Figure 4-10 shows all customizable settings for the deck editor of VWF.

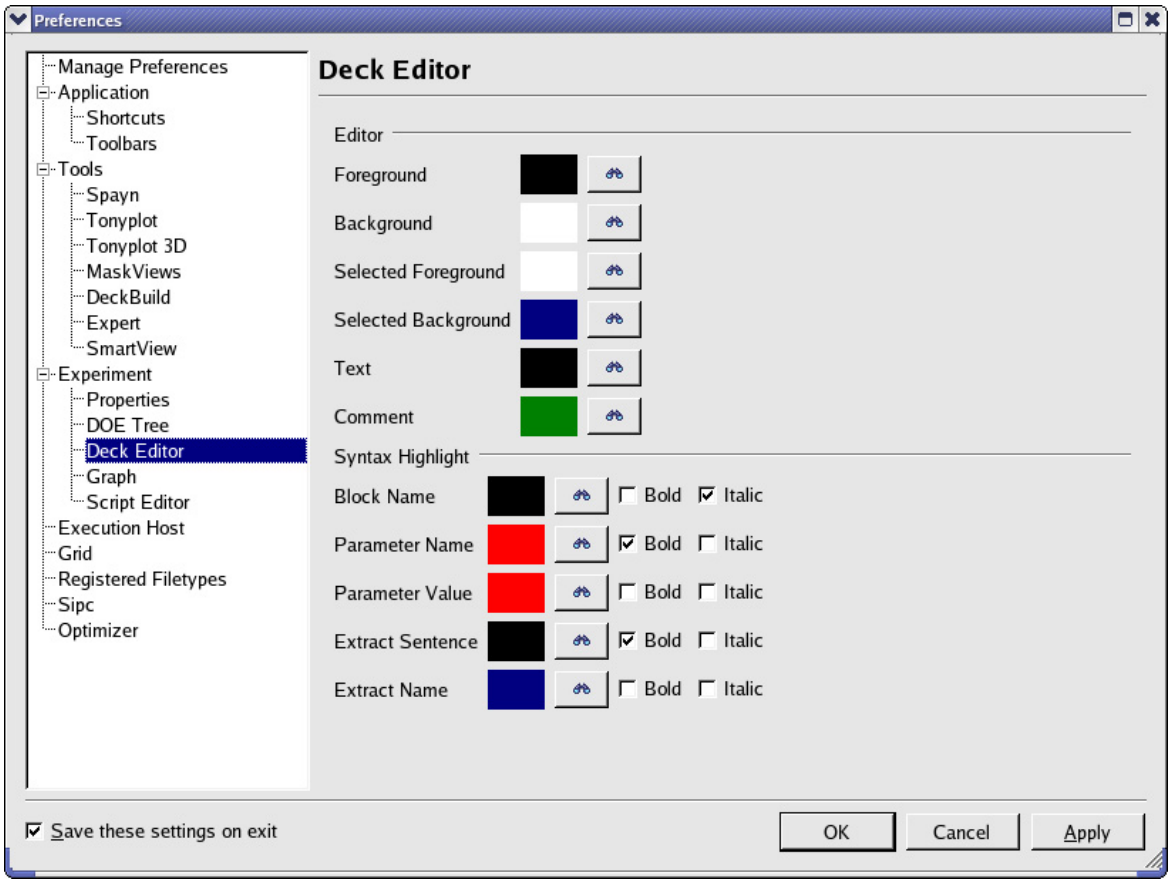


Figure 4-10 Preferences – Deck Editor

Figure 4-11 depicts all settings for the graph widget, which is used for optimization experiments.

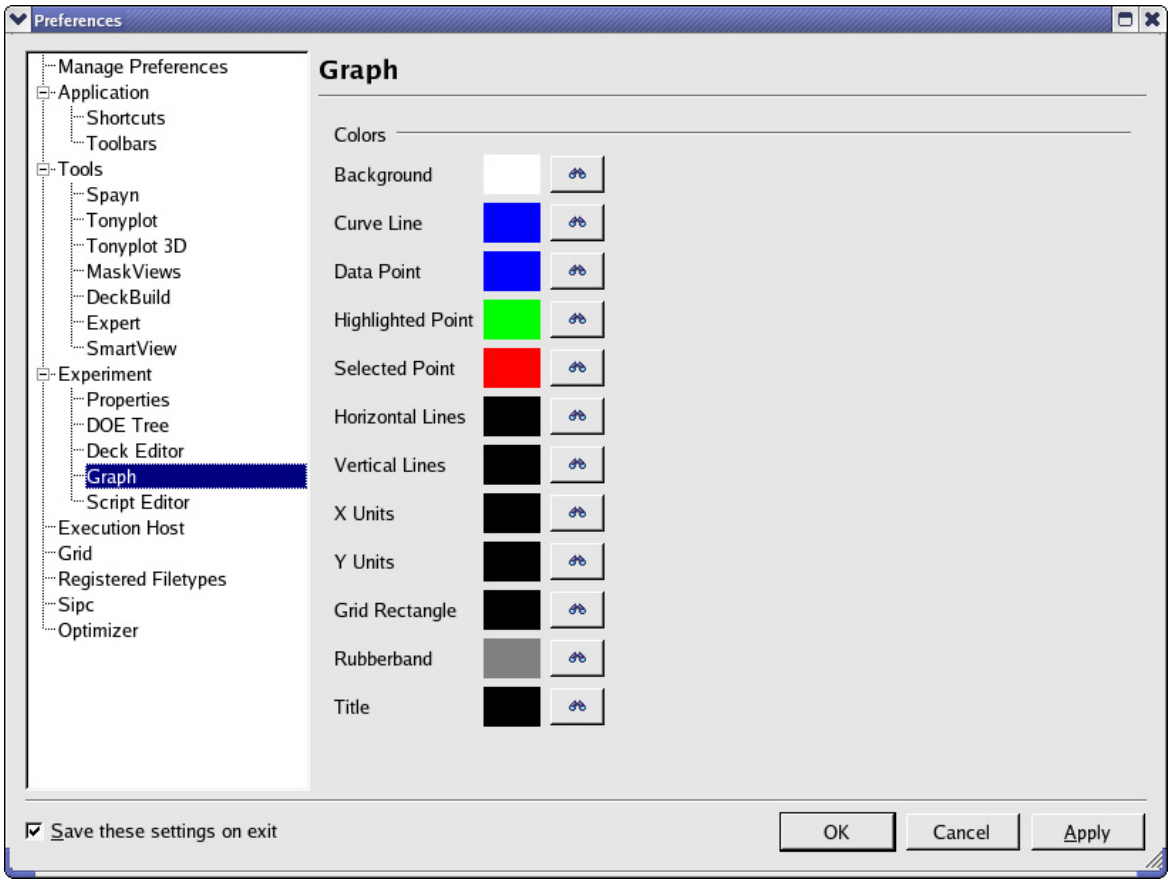


Figure 4-11 Preferences – Graph

Figure 4-12 shows the settings for the Script Editor. You can define the colors used for highlighting as well as settings like tab width and whether to show line numbers.

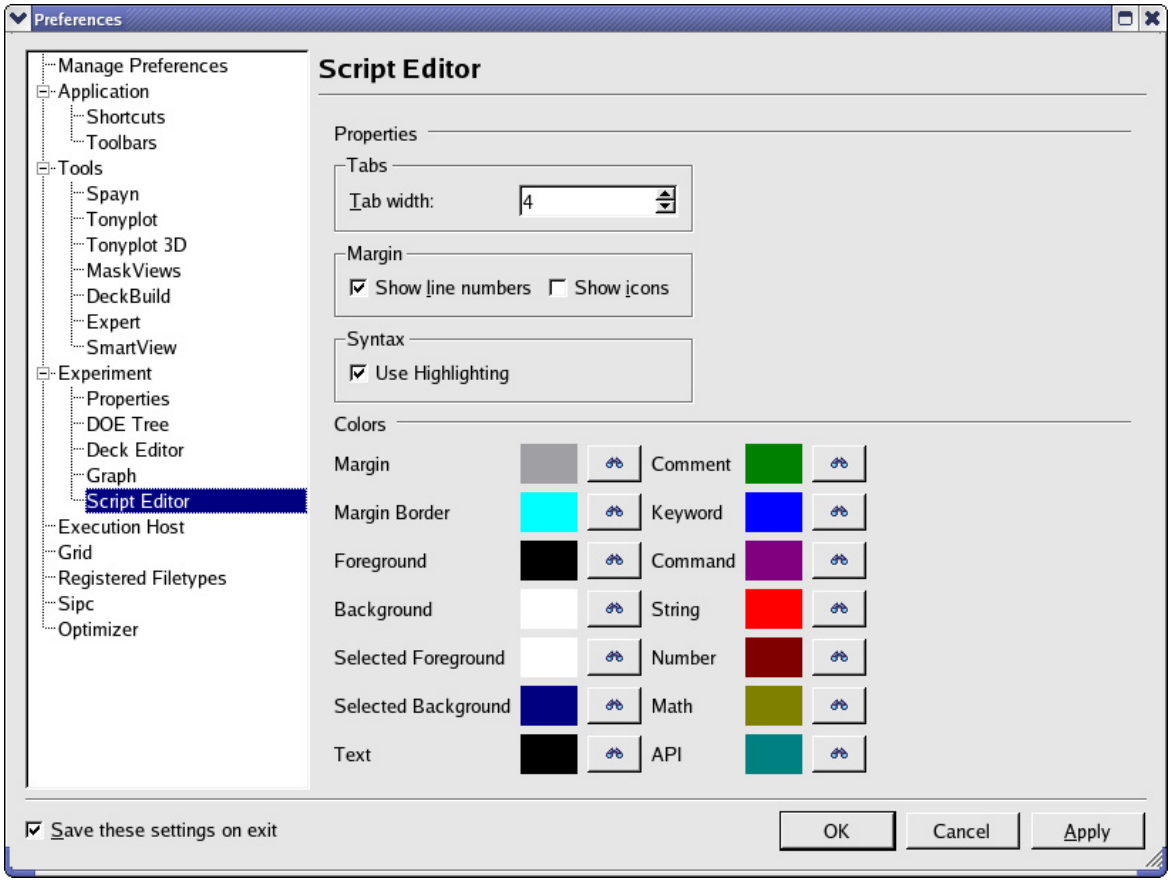


Figure 4-12 Preferences – Script Editor

Figure 4-13 displays the setting of the execution host. You can choose to either run your experiments on your local workstation, or you can choose to use a different host for this. When choosing the **local host** radio button, then the simulation files are stored locally on the `/tmp` directory of your workstation. They cannot be shared with anyone else.

When you use the **other** radio button, then the settings of the host will apply. Particularly, files are kept on the remote machine in the directory, which was selected at install time. The files can be shared with other VWF users.

In this panel, you can also change the values for the disk statistics display of the VWF explorer and main windows. You can change the interval, which is used to update the disk statistics. The default is 30s, which means that the free disk space is checked every 30 seconds. You can also define a warning threshold. If the disk space fall below this value, then the display of the disk space in the explorer and main windows will change to red.

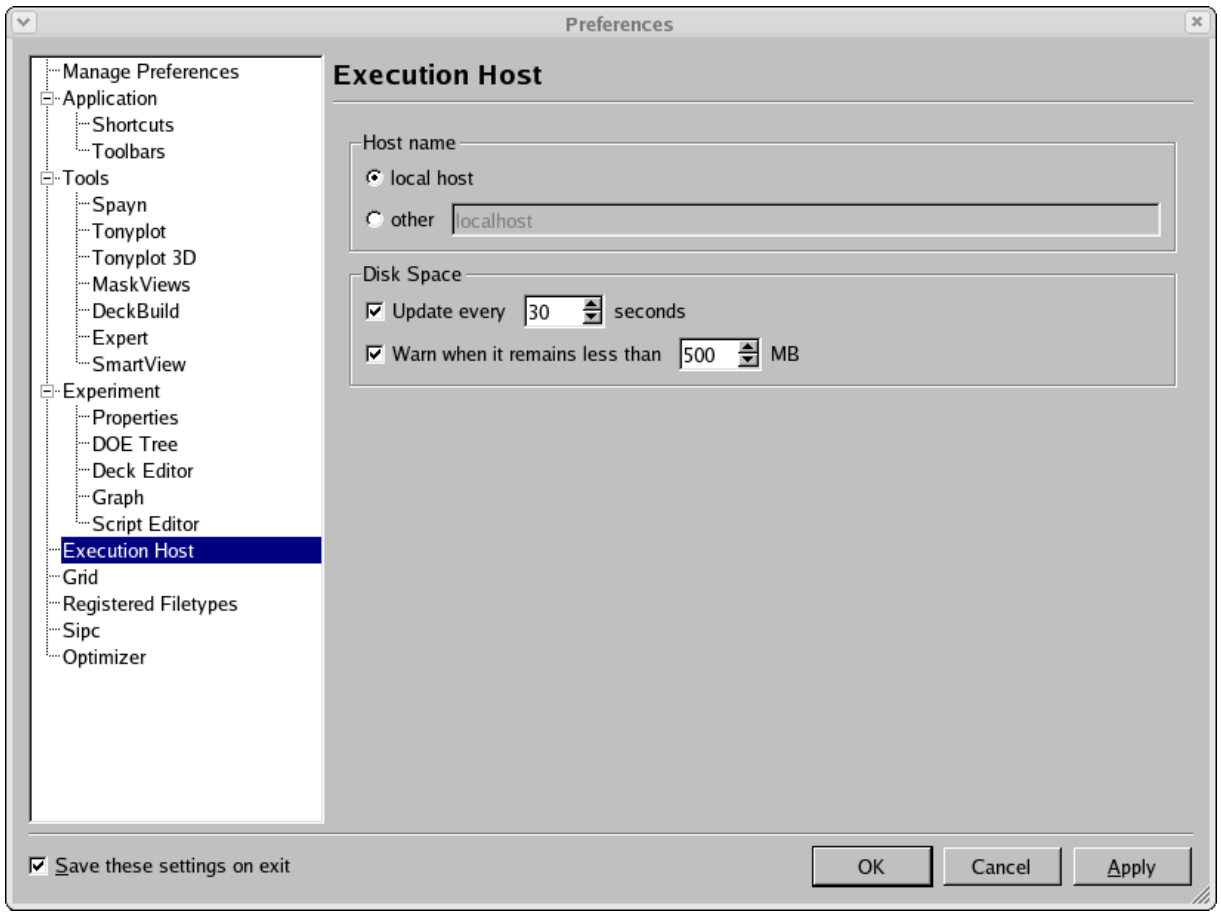


Figure 4-13 Preferences – Execution Host

Figure 4-14 shows all possible settings for the grid environment. Please refer to Section B.5 “Submitting Jobs”, Figure B-13 for further details.

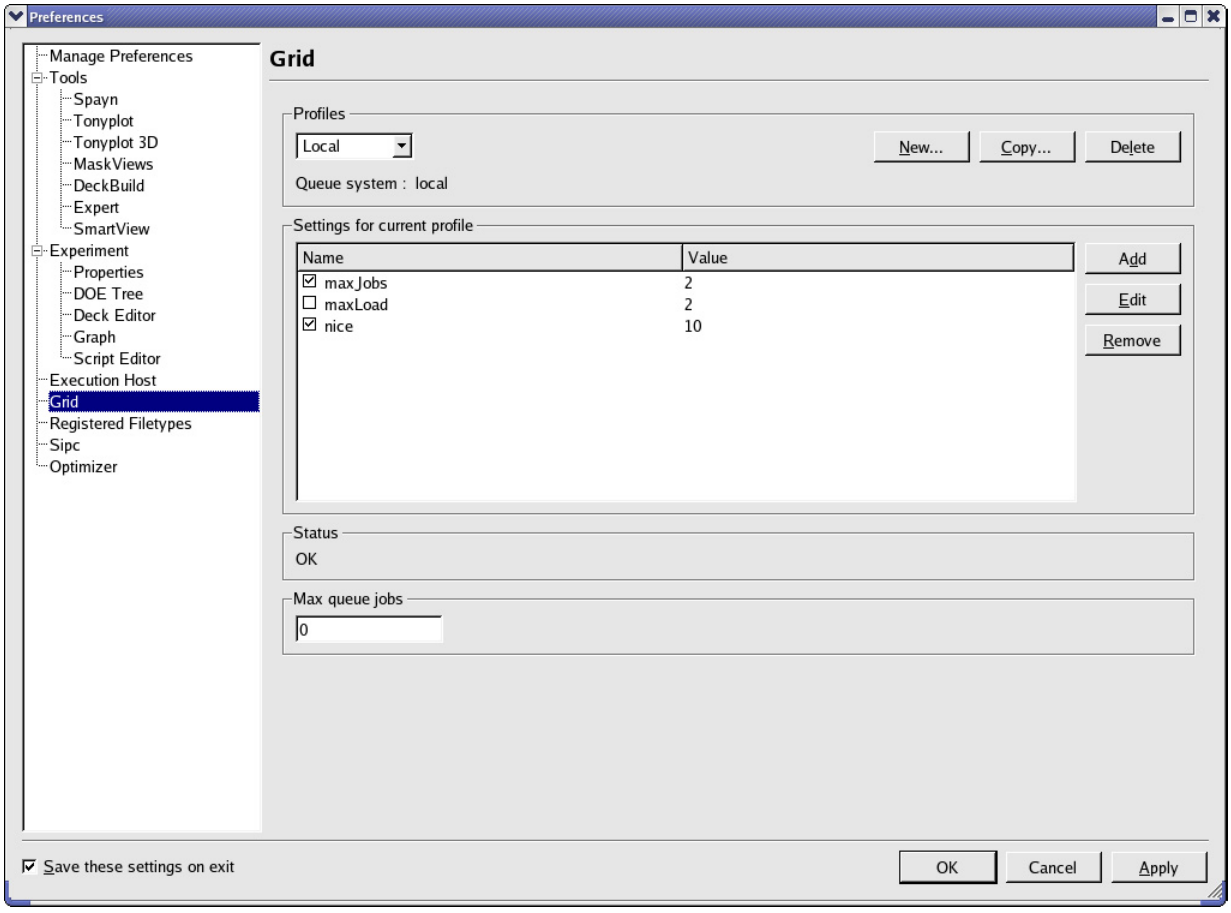


Figure 4-14 Preferences - Grid

Figure 4-15 displays all registered file types. In this pane, file types, which have been assigned a viewer using the Open With dialog, are listed and can be modified. The screen shot shows three entries for file types `.final`, `.jpg`, and `.png`. You can see that the VWF internal text viewer is assigned to open files of type `.final` (e.g., `results.final`) as they are created by DeckBuild during simulation runs. The screen shot further shows that files of type `.png` and `.jpg` are opened using a command called `display` but with a slightly different command line. In the column named **Command**, you can enter any command line to be executed to open a file. The file name is either appended at the end (as it's done for `.jpg` files in this example) or you can use the string `<filename>` as a placeholder as shown in the association for `.png` files.

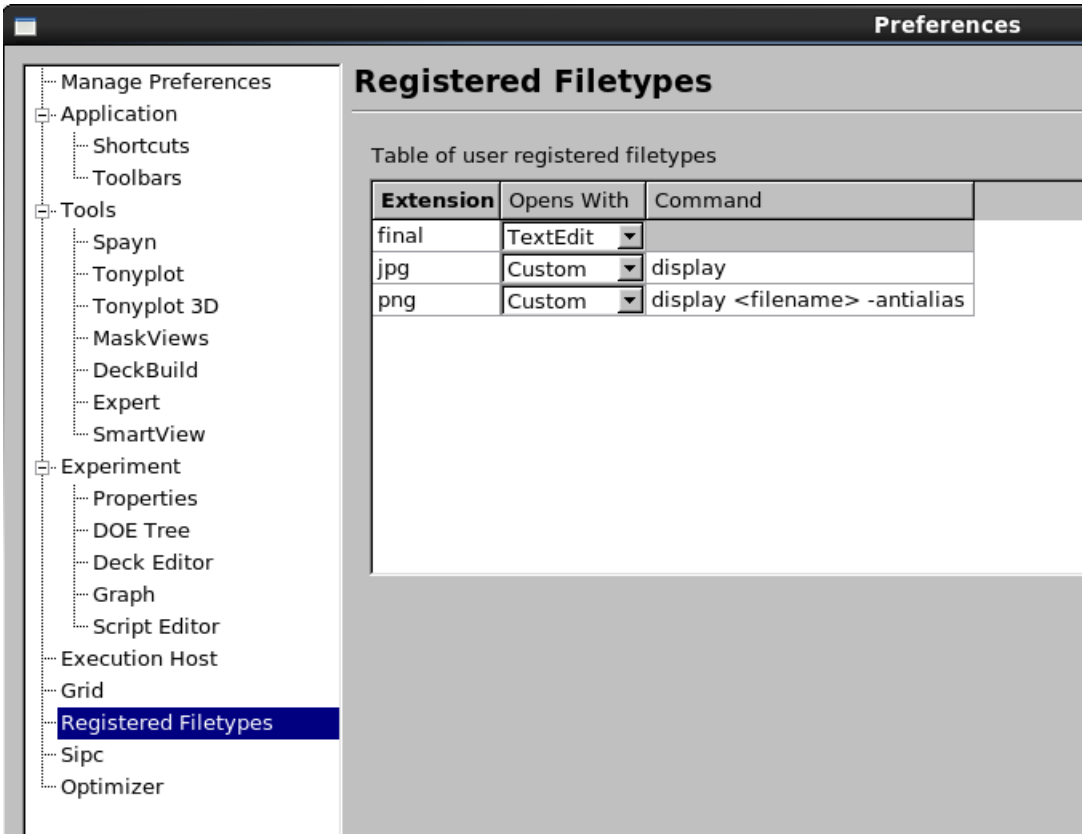


Figure 4-15 Preferences – File Types

Figure 4-16 displays the possible Sipc related setting. Timeouts for starting Sipc applications like TonyPlot or Spayn can be given.

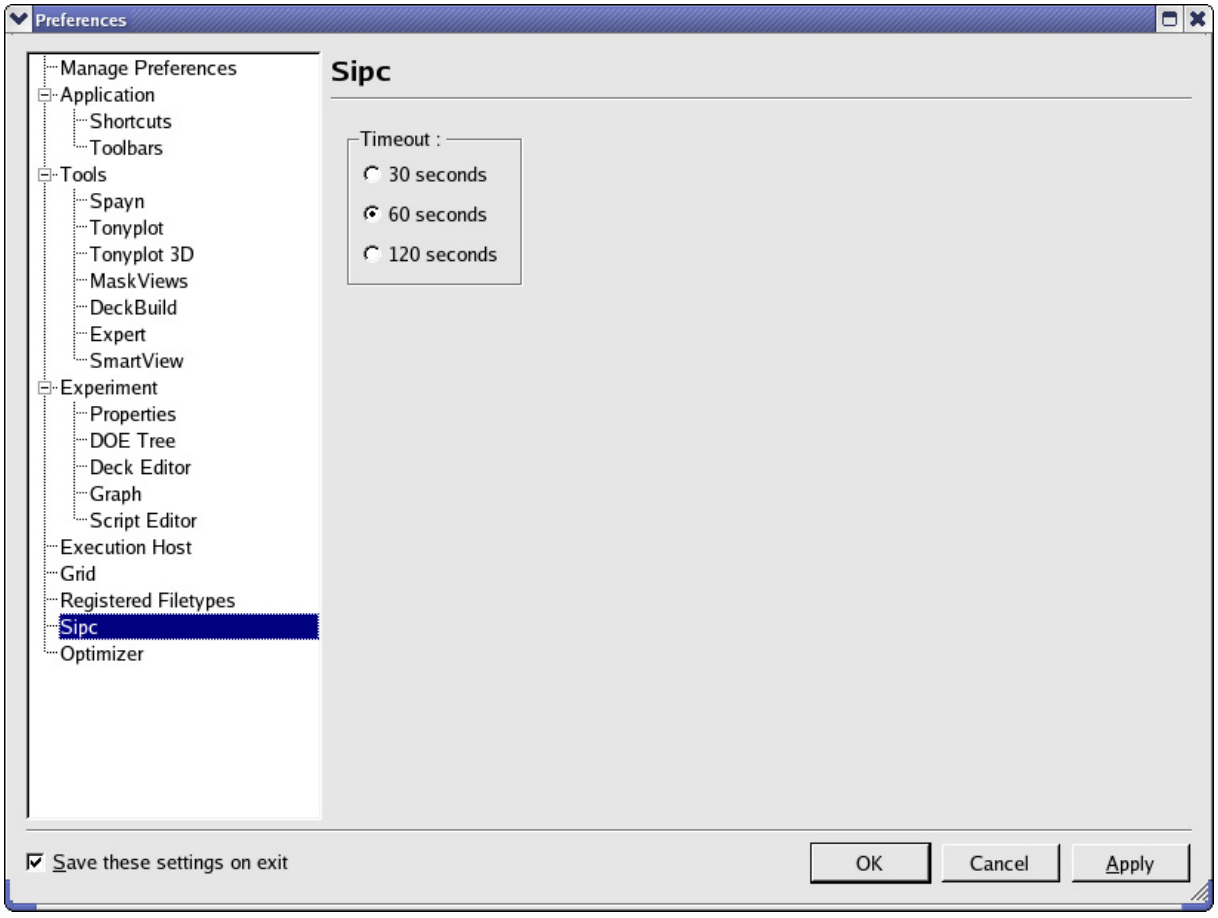


Figure 4-16 Preferences – Sipc

Figure 4-17 depicts preferences for the supported Silvaco optimizers. The values defined here can be assigned in an experiment by using the **Use settings from preferences** functionality when defining optimizer settings. Please refer to Section 6.6.3 “Defining Optimizer Settings”, Figure 6-16 for full details.

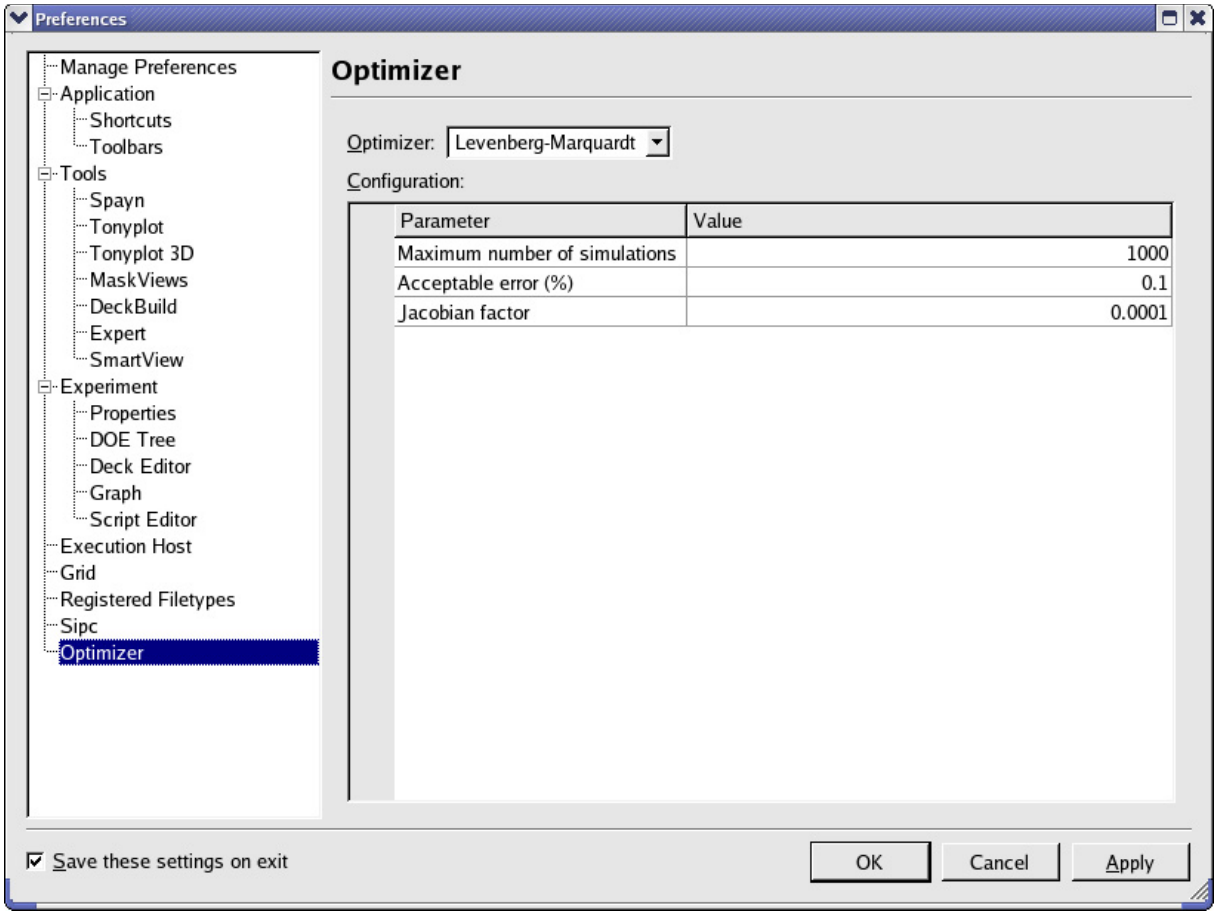


Figure 4-17 Preferences – Optimizer

Chapter 5
Tutorial

5.1 Prerequisites

Before starting the software, you must have a database installation. The VWF database can be located on the same database server as Utmost, however, a separate VWF database must be created. Please see Section 2.3.2 “Database Mode” on how to install firebird and create the VWF database.

In this tutorial, you will prepare a small DOE example. All steps will be outlined in detail and hints are given as necessary. However, the tutorial does not cover Optimization with VWF. Please refer to Chapter 6 “Optimization in VWF” for more details.

5.2 Typical VWF Toolchain

When you run experiments in VWF, there are several tools that are involved. Apart from the VWF software itself, the following tools are used by VWF:

- DeckBuild – takes care to run the simulation deck. Simulations are always run using DeckBuild. It is therefore good practice to try a new deck in DeckBuild first.
- Simulators – any simulator (Atlas, Athena, SmartSpice) that can be used in DeckBuild is also available from VWF.
- TonyPlot – visualization tool for 2D structure files (`.str`) and curve viewer (`.dat` files).
- TonyPlot 3D – visualization tool for 3D structure files (`.str`).
- Spayn – post-processing tool to further analyze the VWF worksheet data. The tool is also used to create RSM plots.
- SmartView – visualization tool to view .raw files as generated by SmartSpice simulations.

5.3 Starting the VWF Software

To start the software simply type `vwf` on the command line. Figure 5-1 depicts the screen, which is shown upon startup. The contents of the window may differ depending on what databases are available. Double-clicking on one of the available databases opens the following dialog.

Note: If the left part of the window does not show any databases, you will have to use **File→Open Database**.

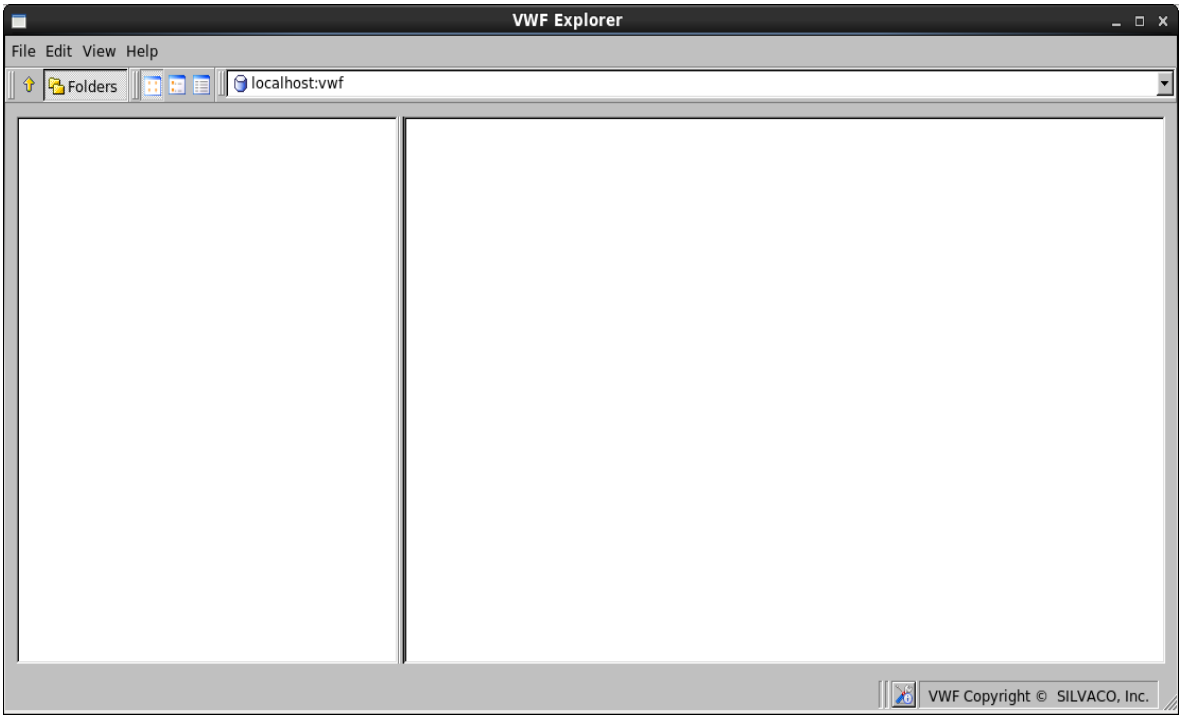


Figure 5-1 Initial VWF Screen

After double-clicking on an existing database entry, or after a new one has been added using **File→ Open Database**, a dialog as shown Figure 5-2 will open.

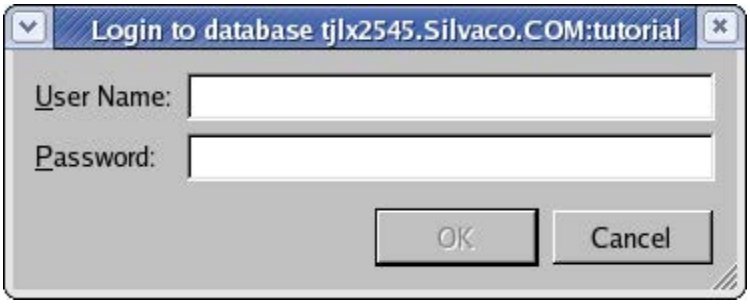


Figure 5-2 Database Opening Dialog

Enter the user name and password. Note that the selected user must already exist in the database. Make sure a database and an account has been created as described in Section A.4 “SRDB Utility”.

5.4 Defining a New Experiment

Figure 5-3 shows the VWF software after a successful login. This figure shows that no experiments have been defined in the database so the database is empty. To define an experiment, first create a directory. To do this, right-click on the shown database (`localhost:tutorial`) and select **New→Directory**. A dialog as shown in Figure 5-4 will open.

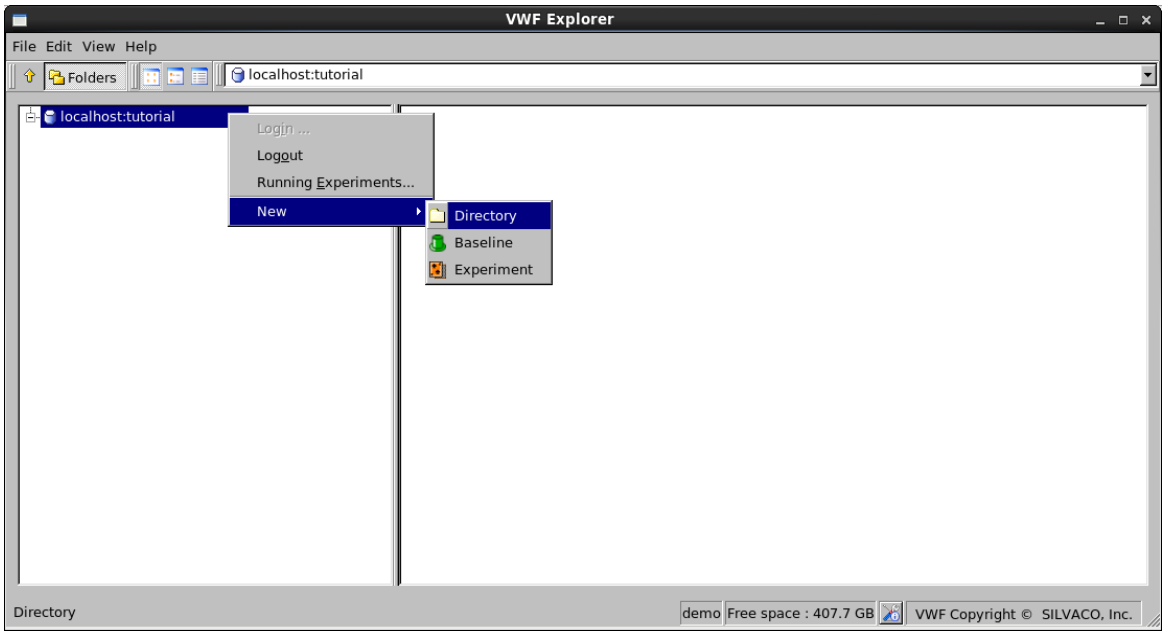


Figure 5-3 Creating a Directory

Figure 5-4 Entering a Directory Name

The name of the directory must be given. Note that no two directories with the same name may exist on any given directory level. The directories created in this dialog are not related to directories in the file-system of your computer or on the network. The sole meaning of directory in this context is to allow you to hierarchically organize experiments.

Figure 5-5 shows the newly created directory.

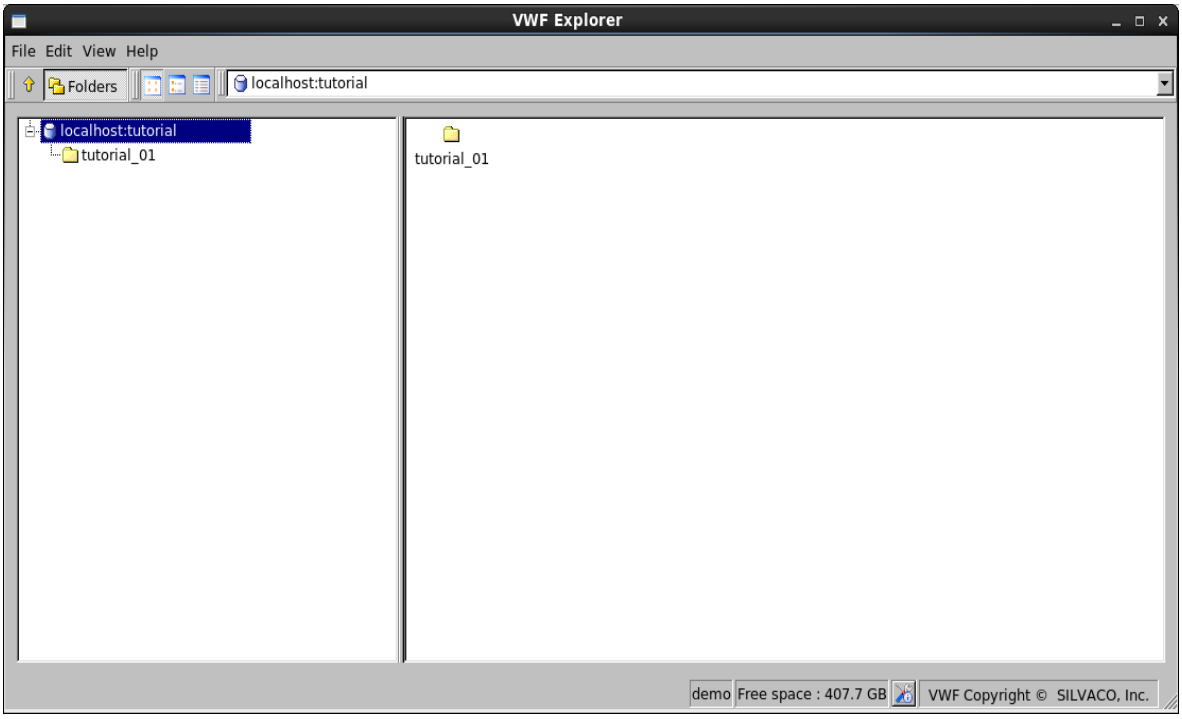


Figure 5-5 Created Directory

After creating a new directory, you must create a baseline in this directory. To create a baseline, first select the directory in the left part of the main window. Then, right-click into the right empty part of the main window and select **New→Baseline** (see Figure 5-6).

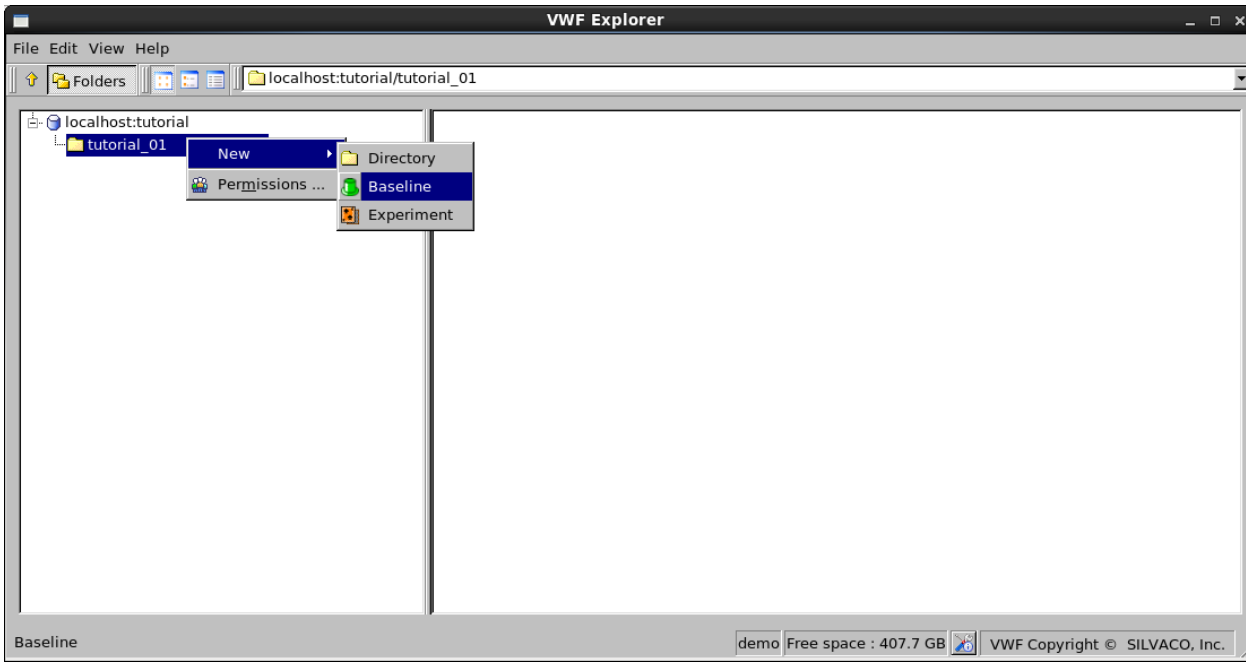


Figure 5-6 Creating a Baseline

Figures 5-7 and 5-8 show how a name for a baseline is entered and how the window looks after an empty baseline has been created.

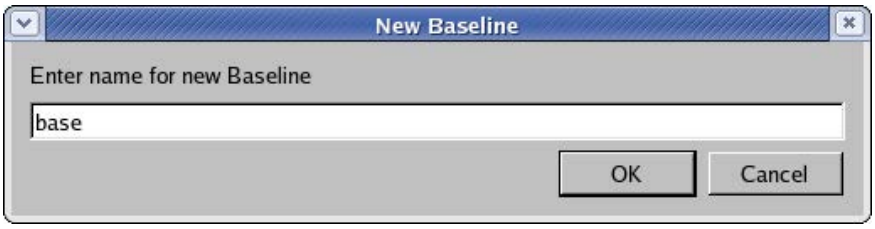


Figure 5-7 Entering Baseline

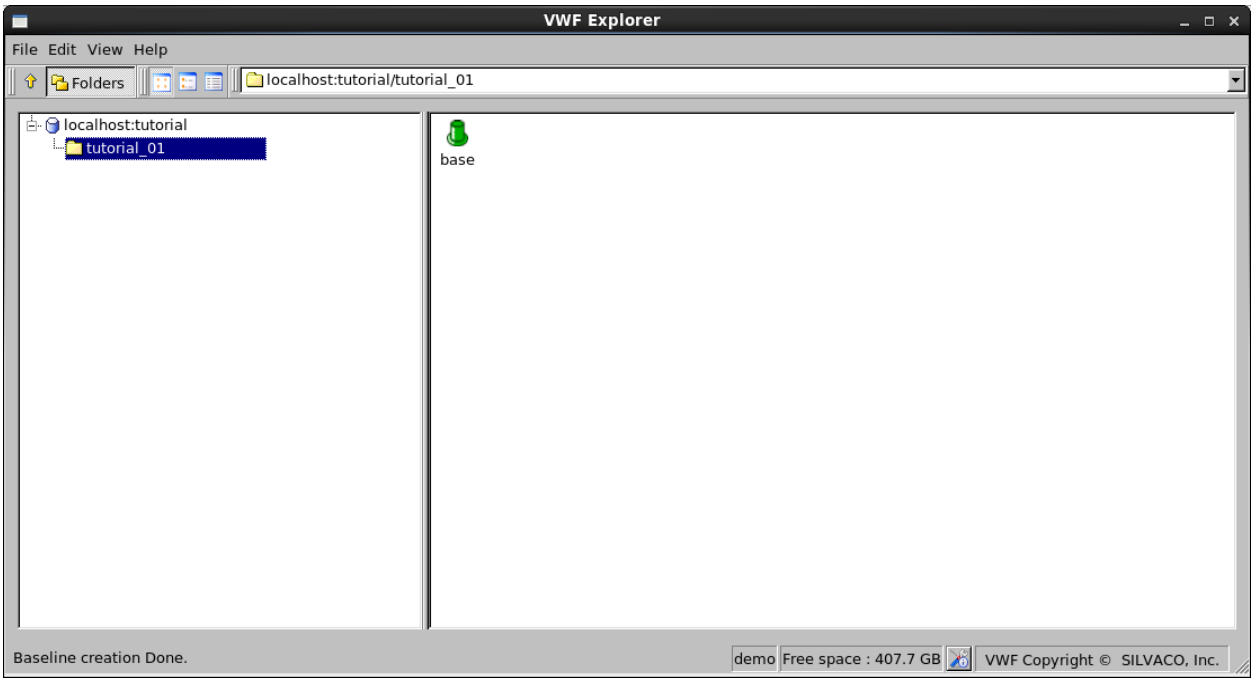


Figure 5-8 Created Baseline

The next step is to import a deck into the defined baseline. This is done by double-clicking on the baseline icon ( ). The dialog will open a prompt for selecting a deck (see Figure 5-9). There are two ways of how a baseline deck can be imported. One is to import a text file (`.in`) directly from the filesystem using the **Import** button, the other is to use the DeckBuild application for this.

In our tutorial, a deck based on one of the examples of DeckBuild was chosen (**Examples→MOS1→example1→mos1ex01.in**). Click the button labeled **DeckBuild** to open the DeckBuild application. Once DeckBuild starts (Figure 5-10), navigate to the **Examples** section and select the first example from the list. To do so, right-click on the button labeled **Main Control** and select the entry called **Examples** from the displayed menu. Another window showing an index of all examples will open. Double-click on the first entry named `MOS1: MOS Application examples`. The content of the window will change and display a list of examples. Double-click the first entry named `1.1 mos1ex01.in : NMOS ...`. The window will change again and display a description of the selected example.

Confirm the selection of the deck to import by pressing **Load example**, then close the examples window. When you are satisfied with your selection close the DeckBuild application again. Another dialog will open to confirm and the deck will then be taken over into VWF as baseline.

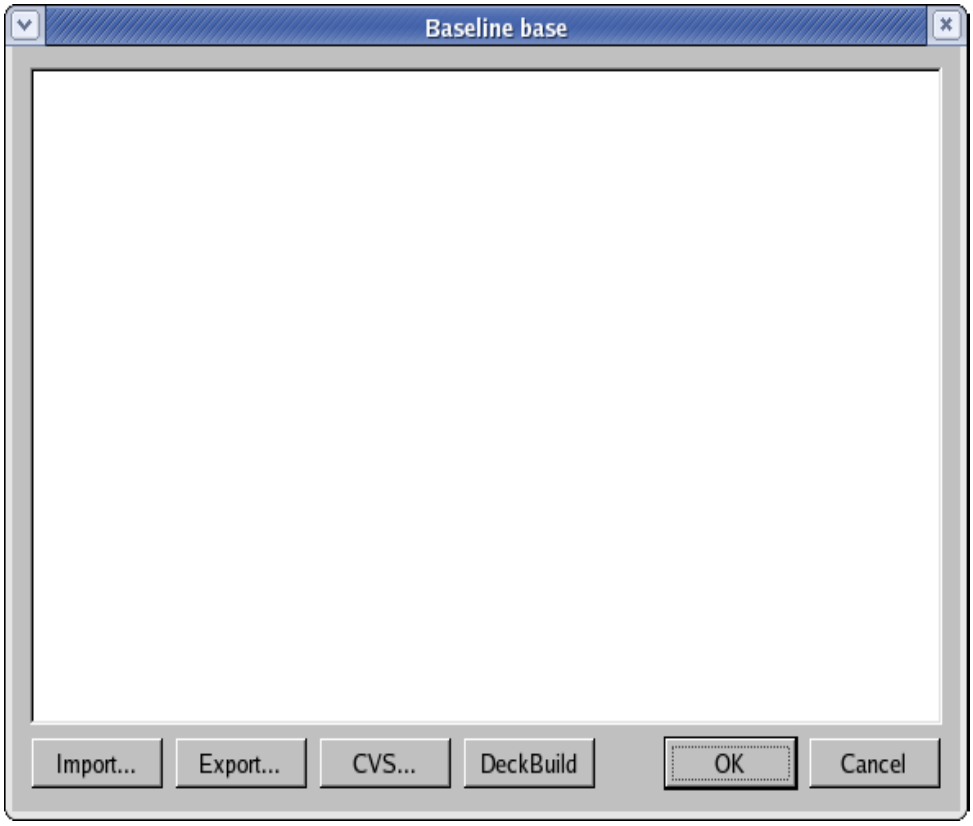


Figure 5-9 Importing a Baseline

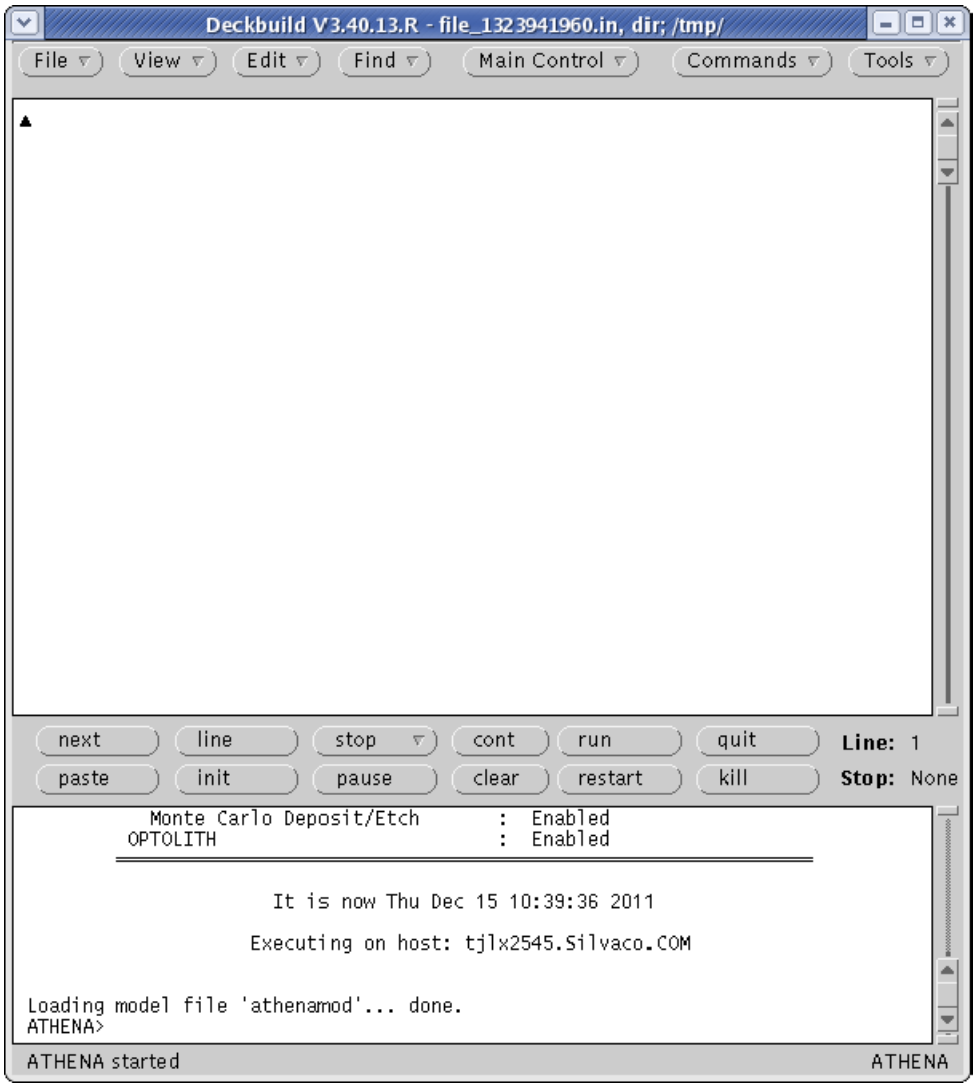


Figure 5-10 Started DeckBuild Application

For reference, Figure 5-11 depicts the second method of importing a deck. Here, the **Import** button was pressed to open a file selection dialog. A default filter is applied to only show files ending in `'.in'` and `'.inp'`.

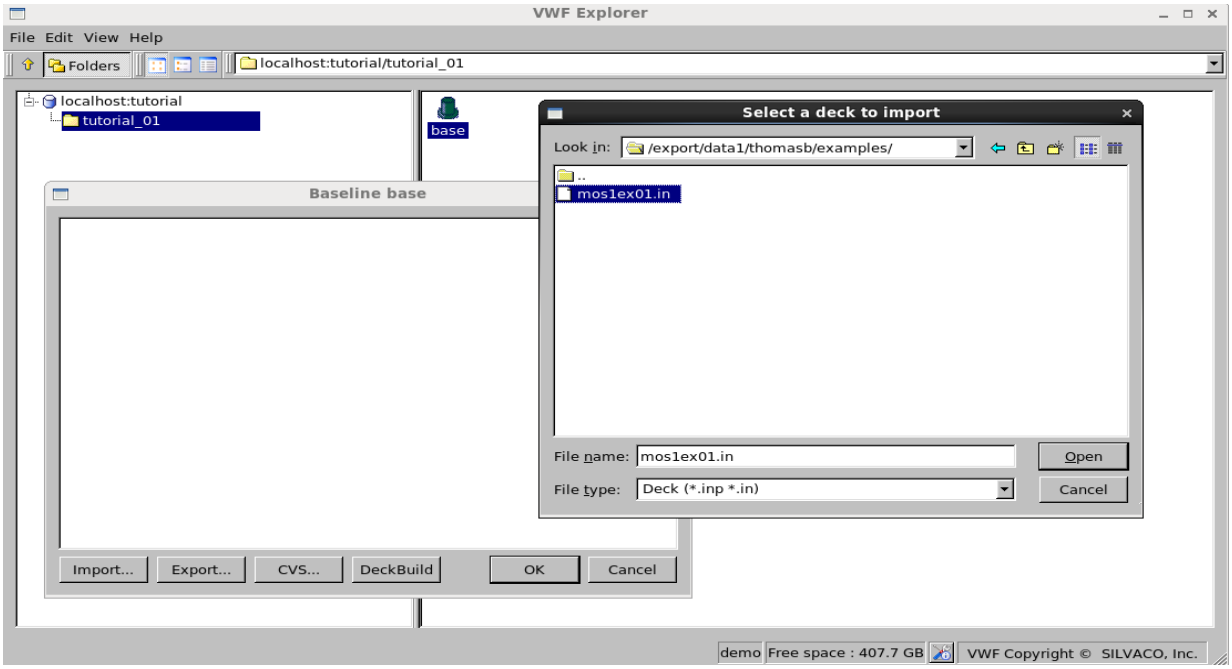


Figure 5-11 Importing Baseline

Figure 5-12 shows the dialog, which opens right after a baseline deck was selected. You can see the deck displayed in the editor pane. Some portions of the deck are highlighted in different colors and in bold font. Scroll through the deck to take a view of the differently formatted areas. You can cancel the import process by clicking on the **Cancel** button. If you select **OK**, the deck will be stored in the database.

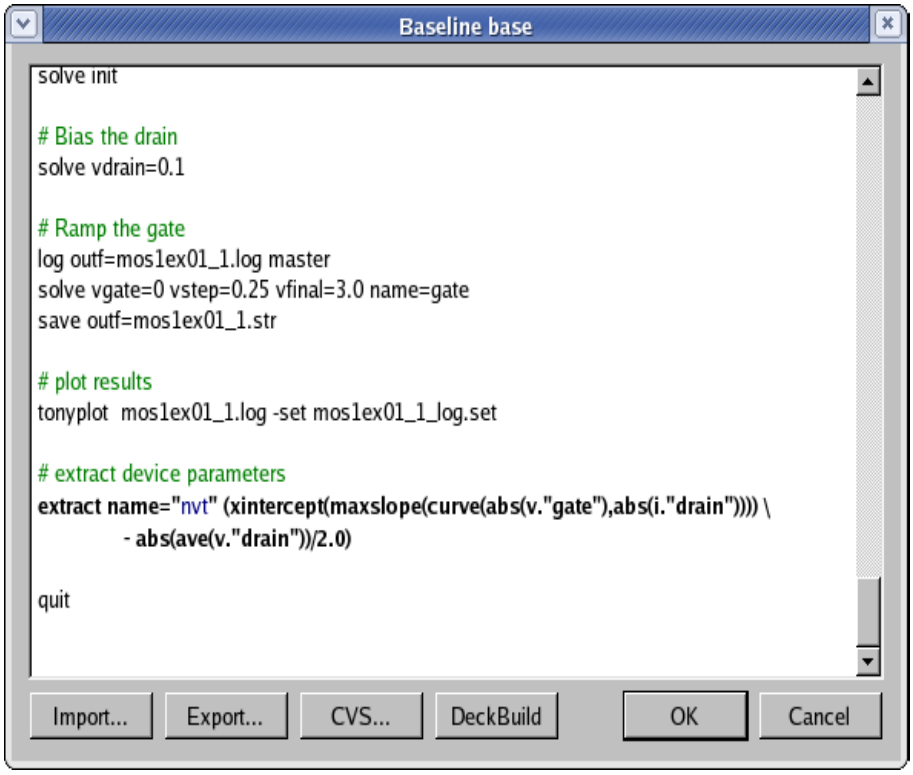


Figure 5-12 Imported Baseline

The next step is to define a new experiment, which is based on the baseline created in the previous step. To do so, right-click on the right part of the window to reveal the context menu as shown in Figure 5-13. Instead of **Baseline**, select **New→Experiment** this time. A dialog will open a prompt for the name of experiment (Figure 5-14). Confirm the name and make sure the type **DOE** is selected, then click **OK** .

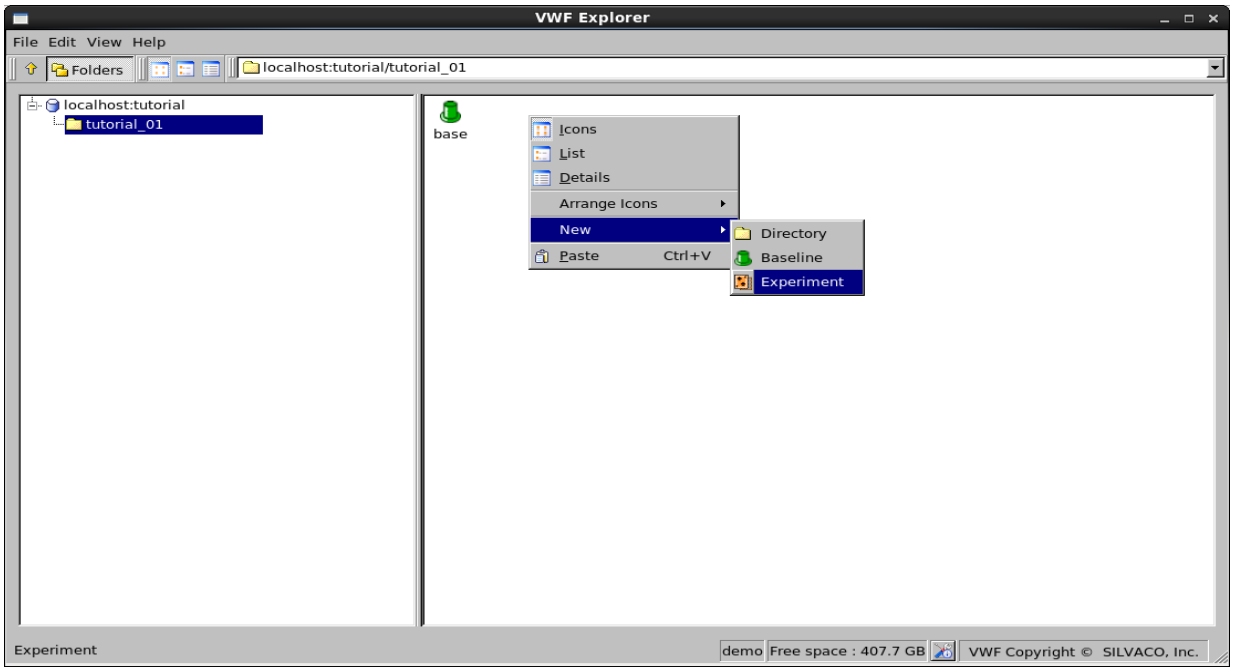


Figure 5-13 Context Menu to Create an Experiment

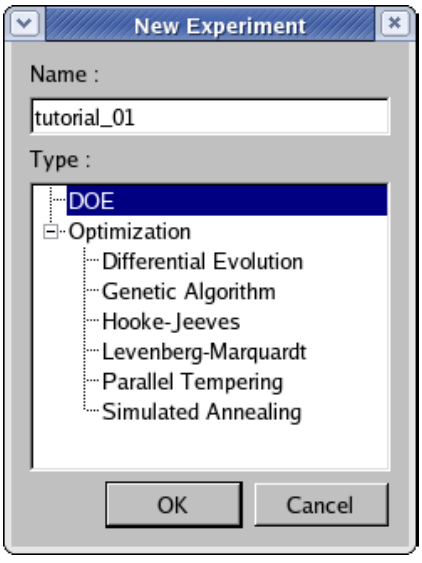


Figure 5-14 Creating DOE Experiment

A new empty experiment will be created. To open the experiment, double-click on it and a window will open (Figure 5-15).

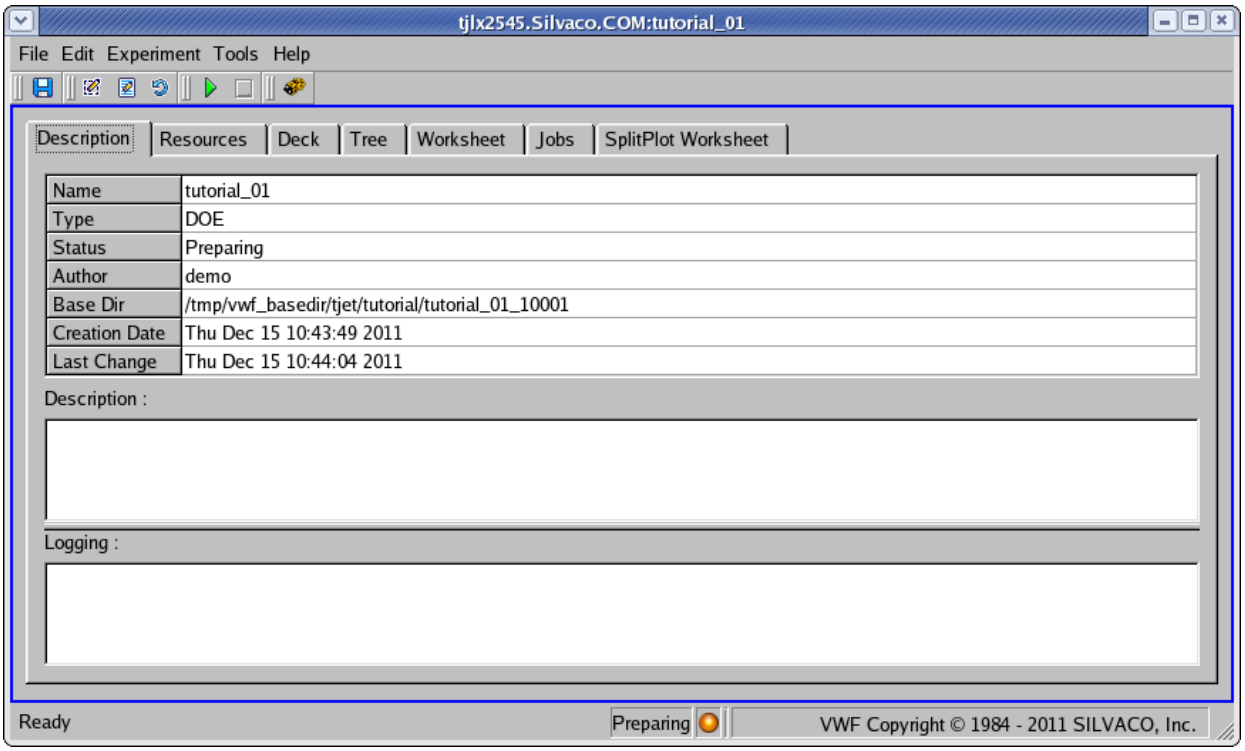


Figure 5-15 New Experiment

The dialog shows some information related to the opened experiment. Among other things, you can see the name and type of experiment (**DOE**), the status, and the owner (**Author**). You can double click in the empty space next to the **Description** label and enter a text of your choice.

The next step is to define split parameters. A split parameter is a parameter in the deck for which several values are assigned when the experiment is run. The following sections will explain how to define these parameters and how to influence the selection process for the values.

Figure 5-16 depicts the contents of the experiment window when the **Deck** tab is selected. A similar view at the deck as the one when a baseline is imported is shown. A notable difference is that no split points can be defined at baseline import or that the baseline cannot be edited. To define a split parameter, right-click on any deck line. In this tutorial, you will create 2 split parameters. To define the first parameter, scroll down to the line reading `"vt adjust implant"`. This line is a comment and has no function in the underlining simulator (here Athena). Right-click the `IMPLANT` statement, which directly follows the line of comment. A context menu will open, which offers several parameters named `boron`, `dose`, `energy`, and `pearson`. Select the parameter called `dose`. The experiment window should now look similar to Figure 5-17. The part of the line identifying the selected parameter (`"dose=9.5e11"`) is now drawn in red color to indicate this parameter has been defined as a split parameter.

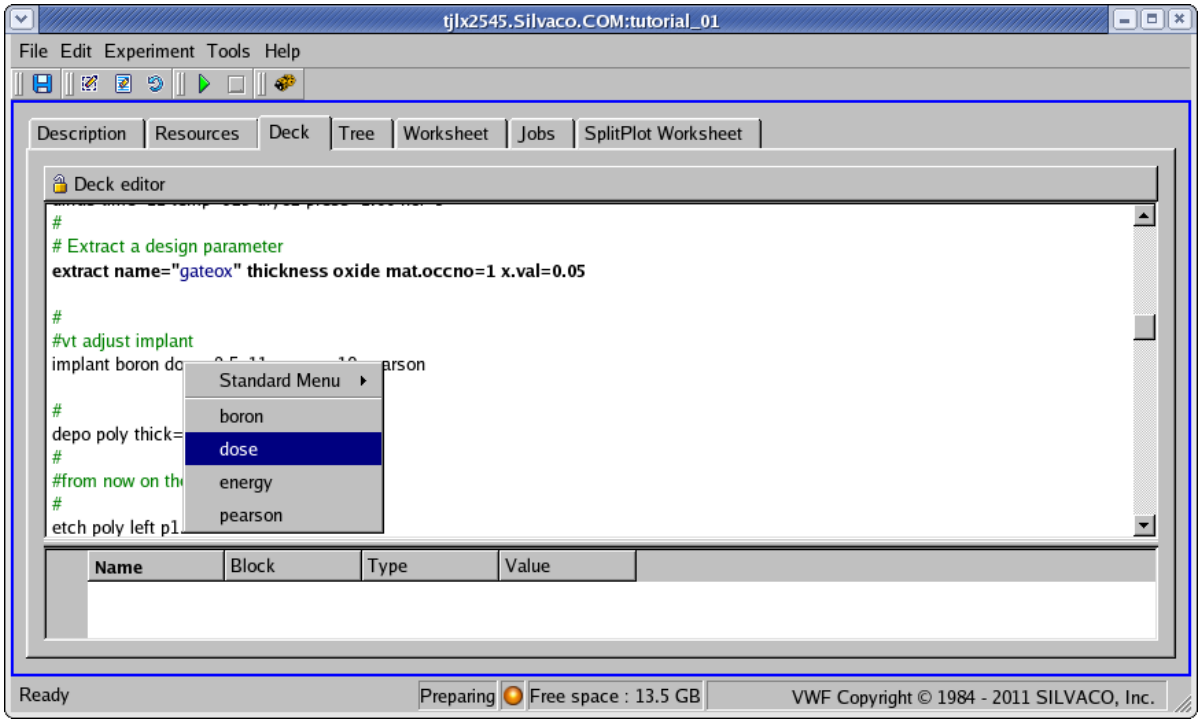


Figure 5-16 Defining Splits

When the context menu is invoked on a line, which already contains split parameter definitions (parameters shown in red color), then a check box is drawn in front of that parameter. This is the situation shown in Figure 5-17. Other variables can now be chosen by selecting one of the unchecked parameters (`boron`, `energy`, or `pearson`). When a checked parameter is chosen again, this has the effect of undefining that very split parameter. In Figure 5-17 if the parameter called dose is chosen, then the view of the deck editor is reverted to what is shown in Figure 5-16.

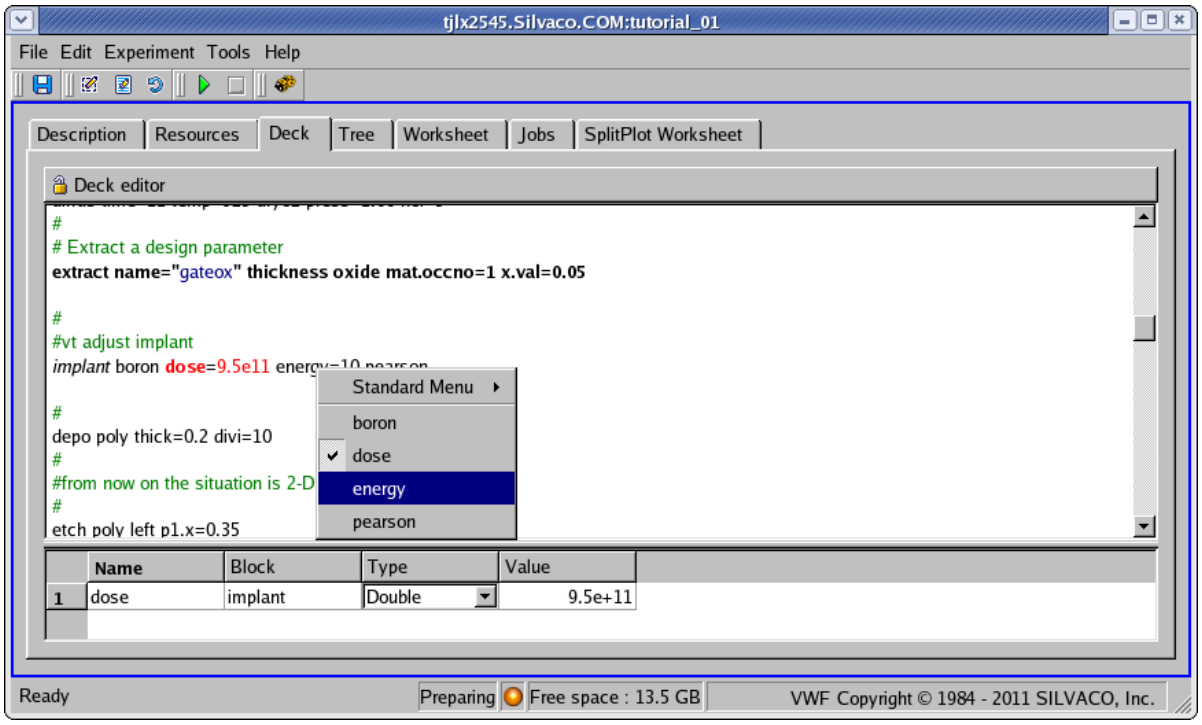


Figure 5-17 Defining Another Split Variable on the Same Line

Select **energy** as the second split parameter from the list of shown parameters. After this, the Deck editor should look as in Figure 5-18. In this example, we will vary dose and energy of the threshold voltage adjust implant to study how these parameters influence the threshold voltage of the device.

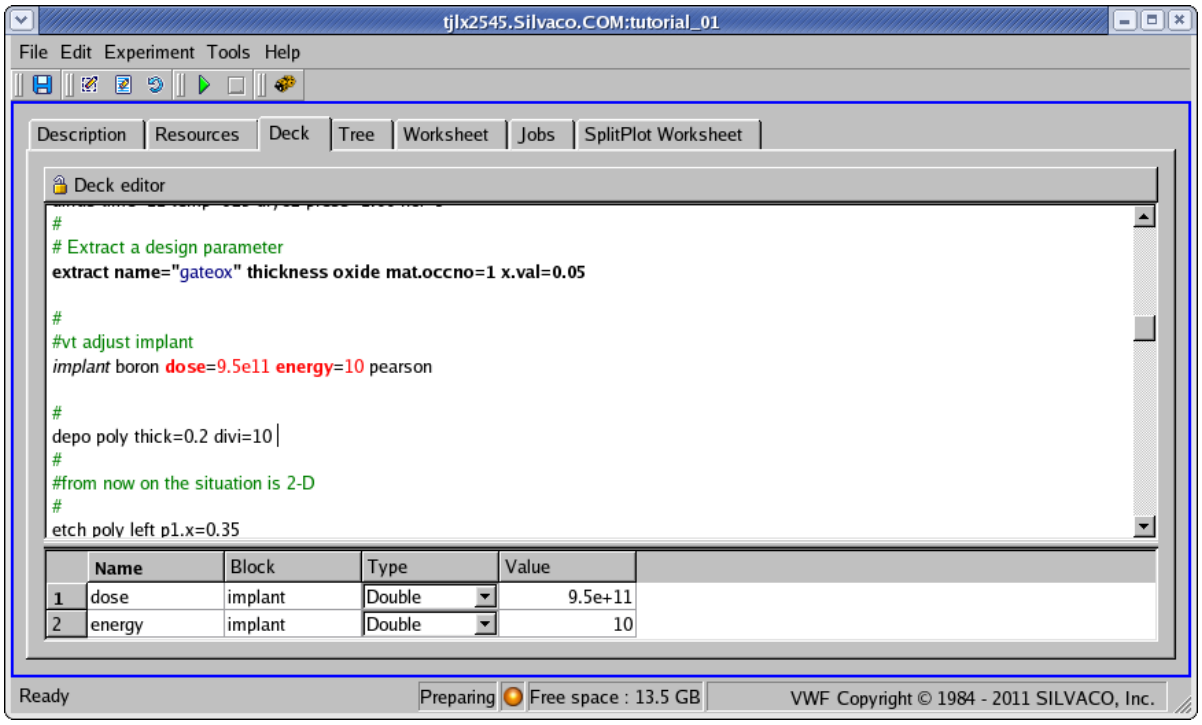


Figure 5-18 Defined Split Parameters

Every parameter selected in a line is formatted in red. The highlighting of the relevant deck portion will always reflect the current collection of chosen split parameters.

Note that the Deck editor allows you to freely edit the deck contents even if split parameters have been defined. The editor preserves split parameter definitions when the deck is edited. If you edit a line with defined split parameters, the parameter definitions of that line are removed and you will have to re-define the parameters of that line after the line editing is finished.

After defining split parameters, select the **Tree** tab to get a view similar to the one depicted in Figure 5-19. It shows a linear graph of all the parameters selected in the previous step. If you followed this tutorial, then the parameters dose and energy of an `IMPLANT` statement will be shown. The very first entry of the tree will always be called root regardless of the parameters you selected. Right-clicking on a node will show a pop-up menu as displayed. The highlighted entry of the menu called **Add Multiple Branches** is one way of adding parameter splits. This function is also available directly from the worksheet and will be explained further down in this tutorial.

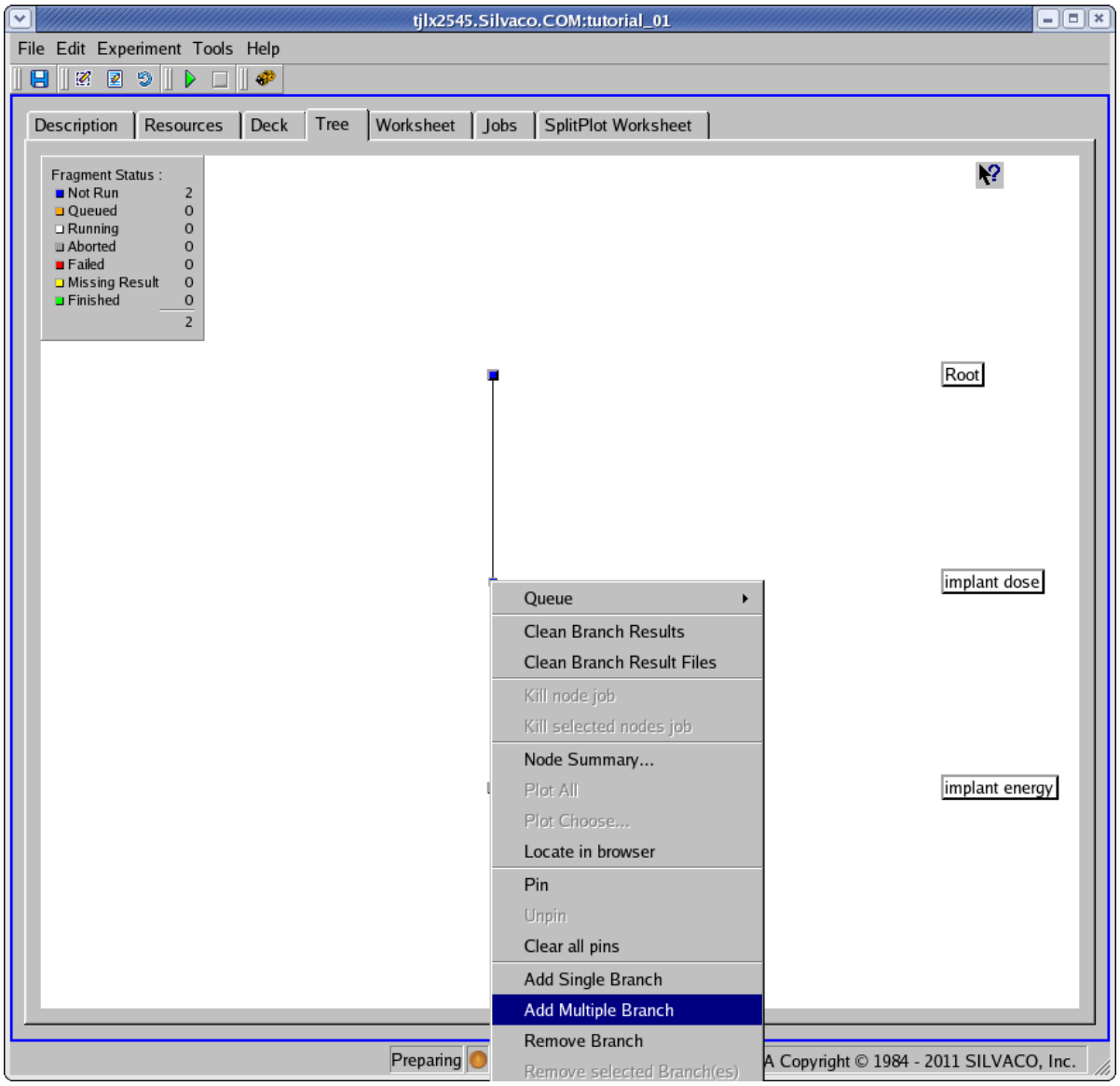


Figure 5-19 Empty Tree

Clicking on the **Worksheet** tab reveals the worksheet view of the experiment. Figure 5-20 depicts the situation without any design strategy. The single entry in the worksheet consists of all split parameters and their nominal values. Split parameters are ordered left to right according to their appearance in the deck. The left most parameter is the one, which is at the topmost position in the deck. Here, this is `dose` of the `IMPLANT` statement. Next in the worksheet, the responses are shown.

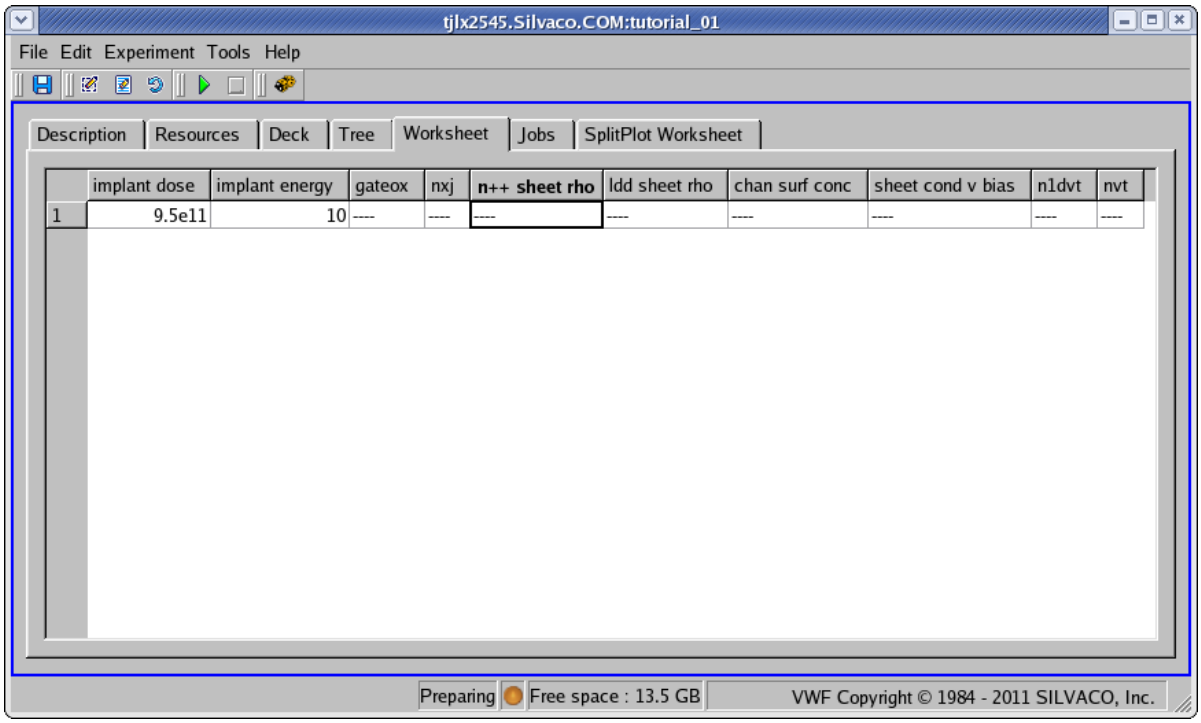


Figure 5-20 Worksheet without Selected DOE Design Strategy

There are now two ways to defining parameter values (splits) to simulate. You can either select a predefined DOE design strategy or manually enter the values. You can also combine these methods. For example, first selecting a design strategy and then removing or adding additional values. Figure 5-21 shows the context menu, which is displayed by right-clicking on the first line in the worksheet. You can use the entries **Add single branch** and **Add multiple branch** to add one or several lines to the worksheet. This is similar to the functionality in VWF 1.xx. The **Remove Branch** entry will delete the selected line. The **Change Value** entry allows you to change the parameter values of the selected line. In this example, select **Design** to open the dialog in Figure 5-22.

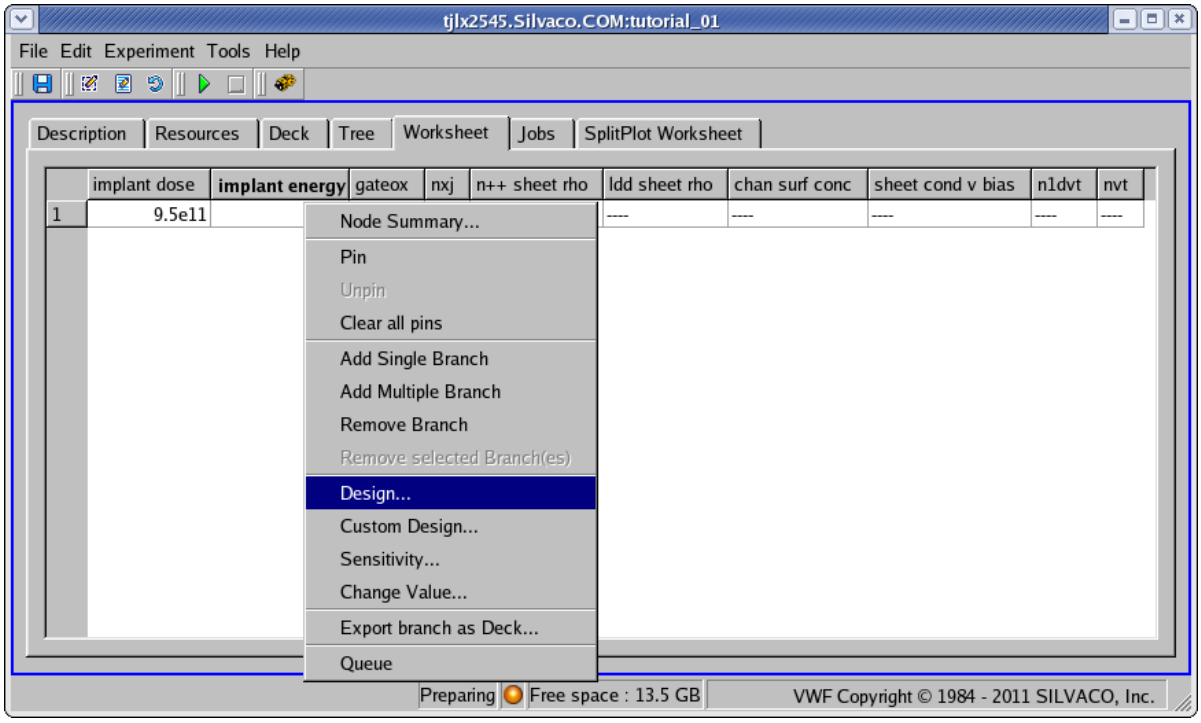


Figure 5-21 Select DOE Design Strategy

Figure 5-22 allows you to select one of the predefined DOE design strategies, to define which parameters to split and between which bounds they will be split. On the top left, there is a pull down menu, which can be used to select a different strategy. The default **Low** and **High** values for a parameter are chosen to be +- 50% of the initial value.

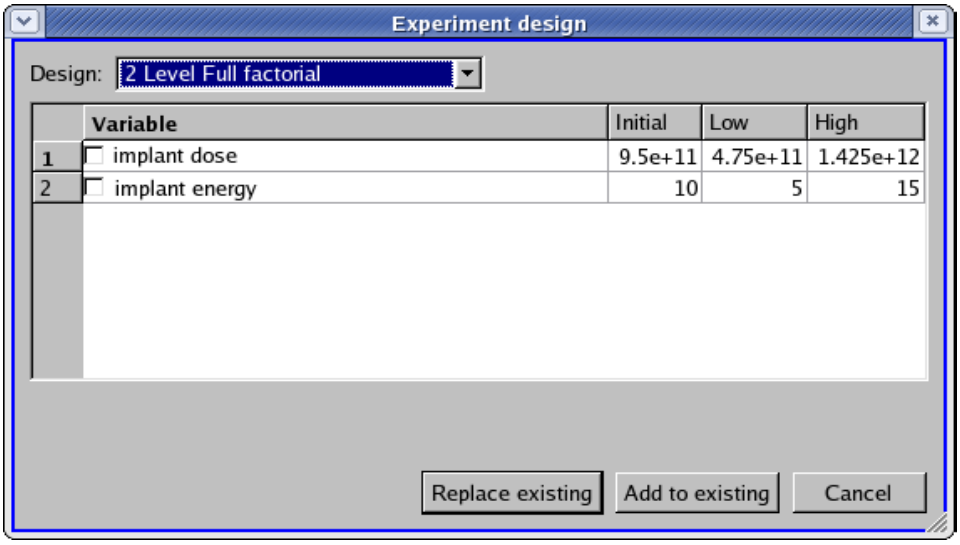


Figure 5-22 DOE Design Strategies

Figure 5-23 shows the situation where a Full-Factorial design has been chosen, all parameters have been selected (check marks at the left), and bounds have been entered for the parameters.

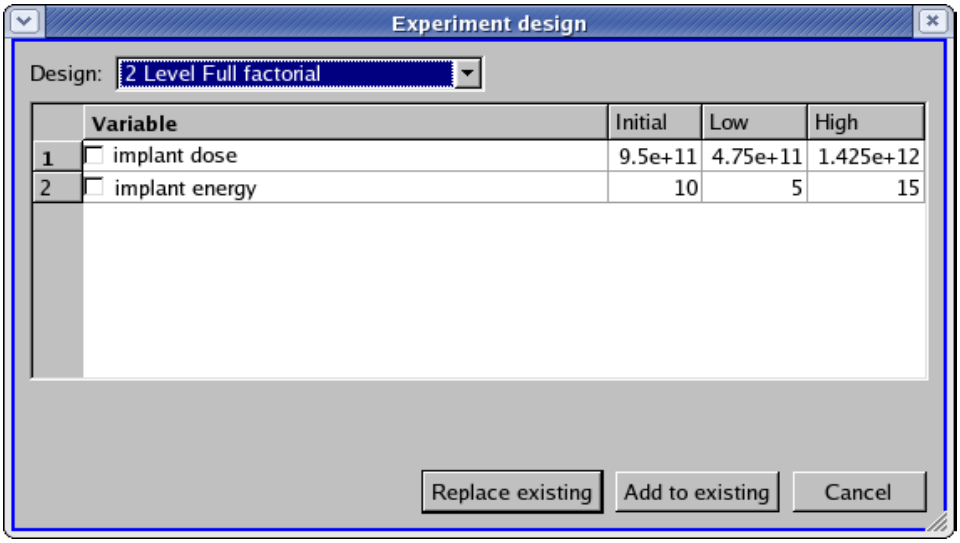


Figure 5-23 Chosen DOE strategy

By clicking **Add to existing** or **Replace existing**, the split parameter entries are created and the Worksheet view changes accordingly. The difference between adding and replacing is that the latter will remove any previously defined splits. In this example, it doesn't make a difference as this is the first time splits are defined. After selecting add (or replace), the worksheet should look similar to the one shown in Figure 5-24. Navigating to the **Tree** tab shows the changed tree view (Figure 5-25).

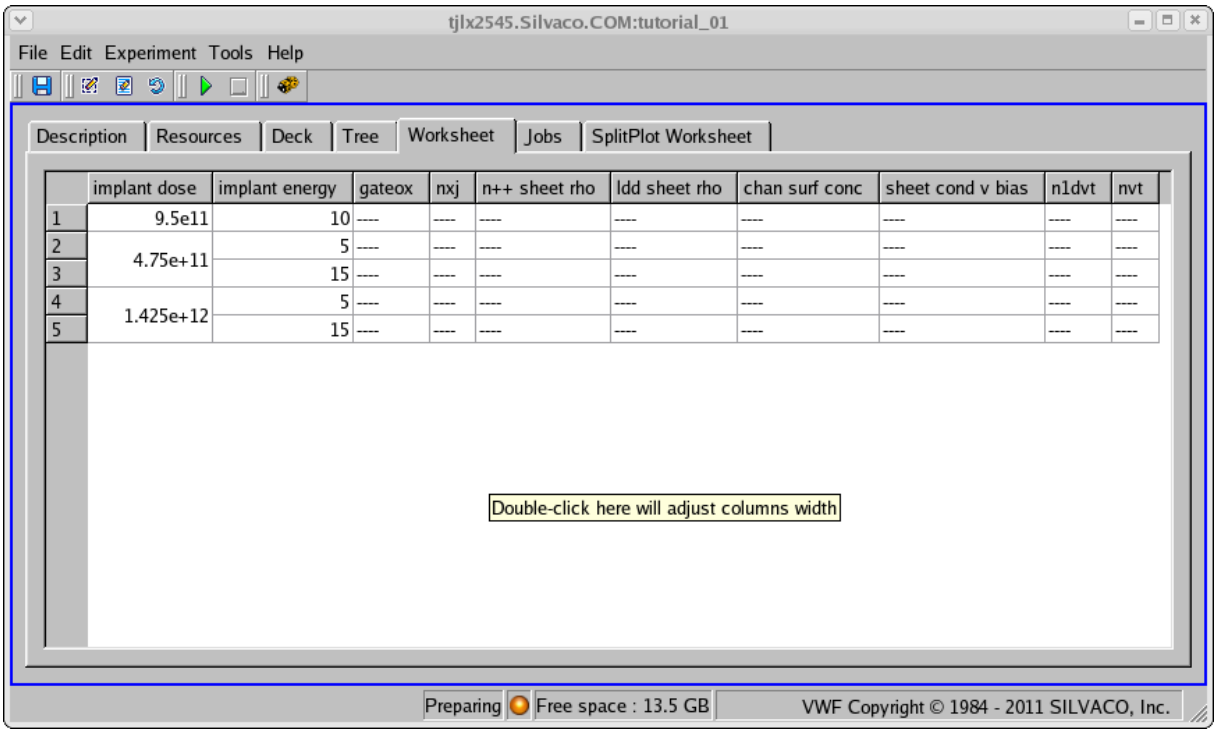

tjlx2545.Silvaco.COM:tutorial_01
File Edit Experiment Tools Help
Description Resources Deck Tree Worksheet Jobs SplitPlot Worksheet
implant dose implant energy gateox nxj n++ sheet rho ldd sheet rho chan surf conc sheet cond v bias n1dvt nvt
1 9.5e11 10 ---- ---- ---- ---- ---- ---- ---- ----
2 4.75e+11 5 ---- ---- ---- ---- ---- ---- ---- ----
3 15 ---- ---- ---- ---- ---- ---- ---- ----
4 1.425e+12 5 ---- ---- ---- ---- ---- ---- ---- ----
5 15 ---- ---- ---- ---- ---- ---- ---- ----
Double-click here will adjust columns width
Preparing
Free space : 13.5 GB
VWF Copyright © 1984 - 2011 SILVACO, Inc.

Figure 5-24 Populated Worksheet

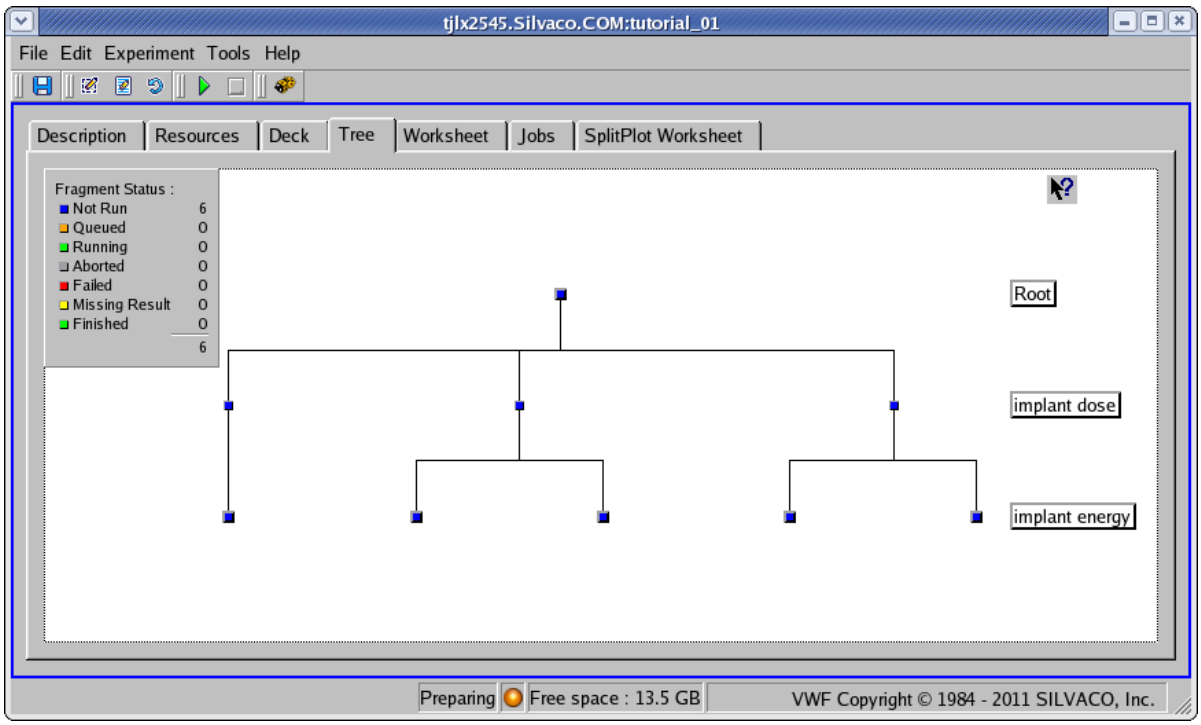


Figure 5-25 Populated Tree

The experiment has now been fully defined and can be saved by using Ctrl-S or selecting **File→Save**. After the experiment has been saved the blue disk shaped icon will turn gray to indicate there are no more outstanding changes to save. The color of the icon will change to blue again as soon you perform more edit operations.

You can terminate and restart the VWF between any of the above mentioned steps without losing any of the entered data. All the experiment definition is stored in the database and will be retrieved whenever an experiment is opened.

5.5 Running an Experiment

Figure 5-26 shows the entries of the **Experiment** menu of the Experiment window.

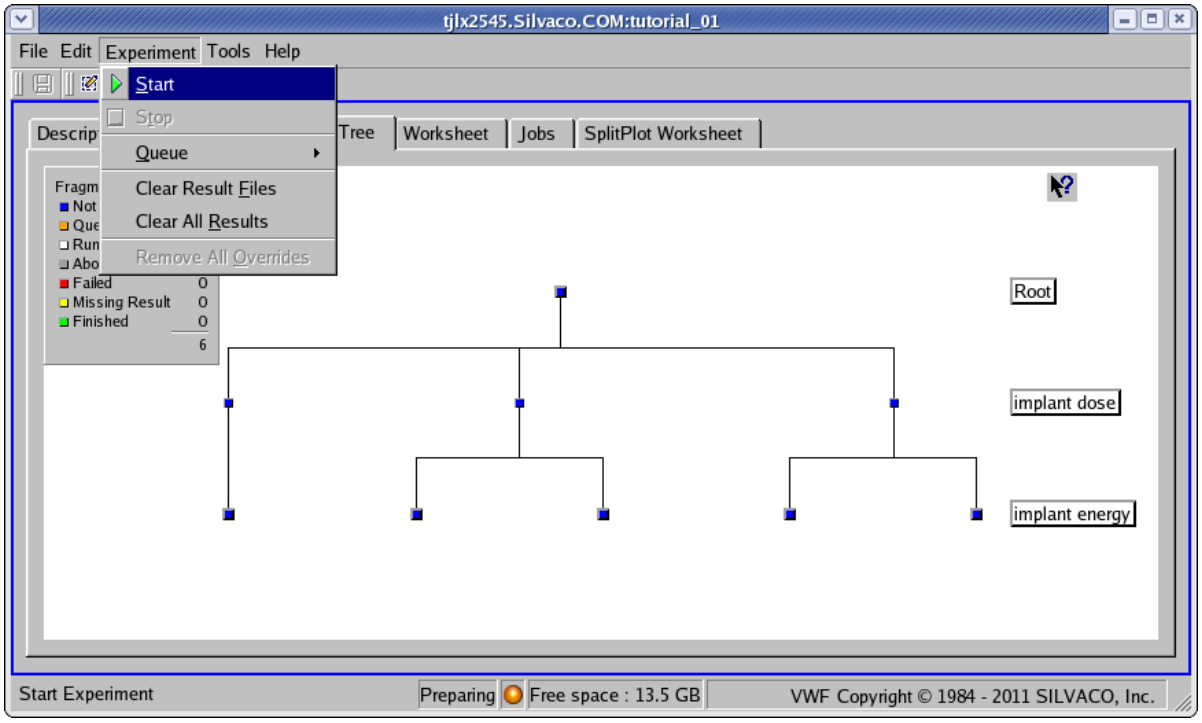


Figure 5-26 Starting an Experiment

Starting an experiment has the effect of queuing simulation jobs in the underlying job farming system. VWF supports three job-farming systems. These are the Open Grid Scheduler (OGS), the Load Sharing Facility (LSF), and a local (embedded) queuing system, which allows you to run jobs on the local machine only. In the latter case, the system detects the number of available CPUs. By default, it executes no more than one job per CPU at a time. It is possible to tune this behavior in the preferences section, where you can enter the maximum number of jobs, which should be running at any given time. Additionally to the jobs limit, you can also define a load limit. VWF tries not to exceed either of the two limits. The load limit is particularly useful if the machine is also used for running jobs outside VWF. There is also a setting called **nice**. This can be used to define a nice increment level. All processes started by the local queue will have their nice level incremented by the value given in this setting. The nice level is relative to the nice level VWF runs at. For instance, if VWF runs at nice level 5 and you set the increment for the local queue to 10, this means that the processes started by the local queue will run at a level of 15. The default value for nice is 10, meaning that all started processes will be incremented by a value of 10.

Before jobs are actually queued into the underlying job-farming system, you need to select which parts of the tree to simulate. This can either be the whole tree or a subset of it. Figure 5-27 shows how to select a subset of the tree using **Add branch** of the **Queue** submenu.

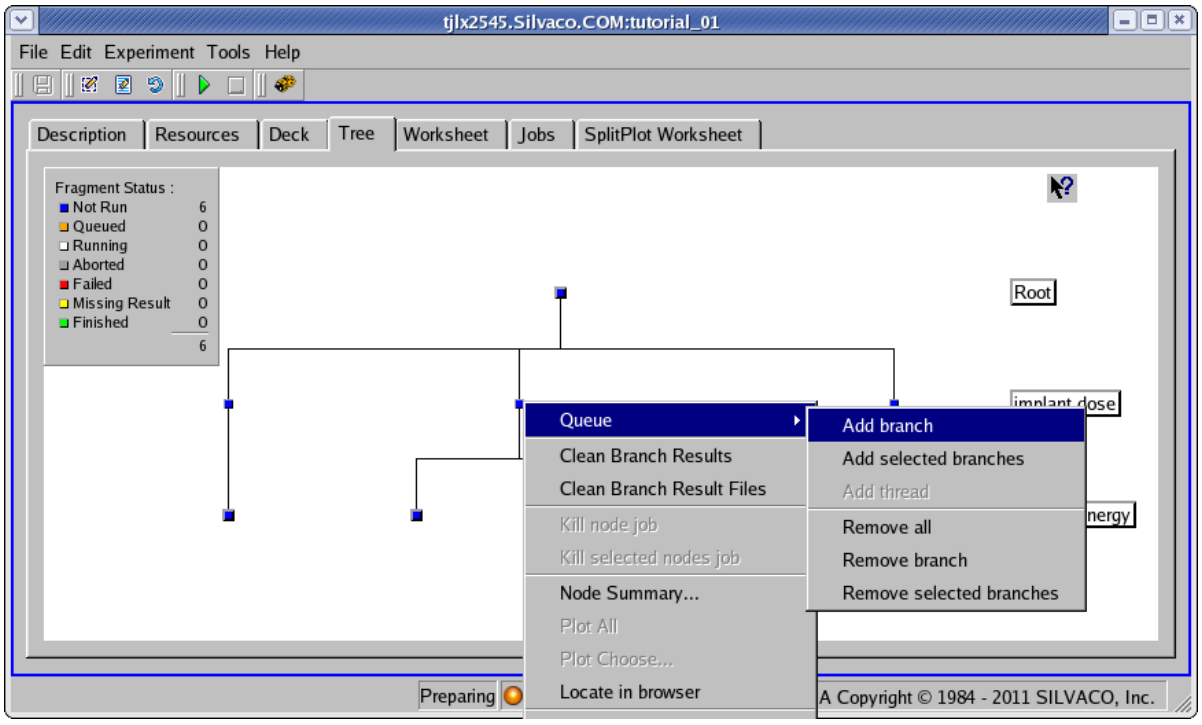


Figure 5-27 Context Menu to Add a Branch to the Queue

Figure 5-28 depicts the situation after the branch has been added to the queue. To distinguish queued from dequeued jobs, queued jobs are drawn in orange. You can see that, although not explicitly selected, the top level node is also drawn in orange. This is necessary since no results are available for the top level node at this time. The node was auto selected.

Note: When you later rerun a sub tree of an experiment, the results of any upper level node will always be re-used and simulations will always start at the lowest possible level.

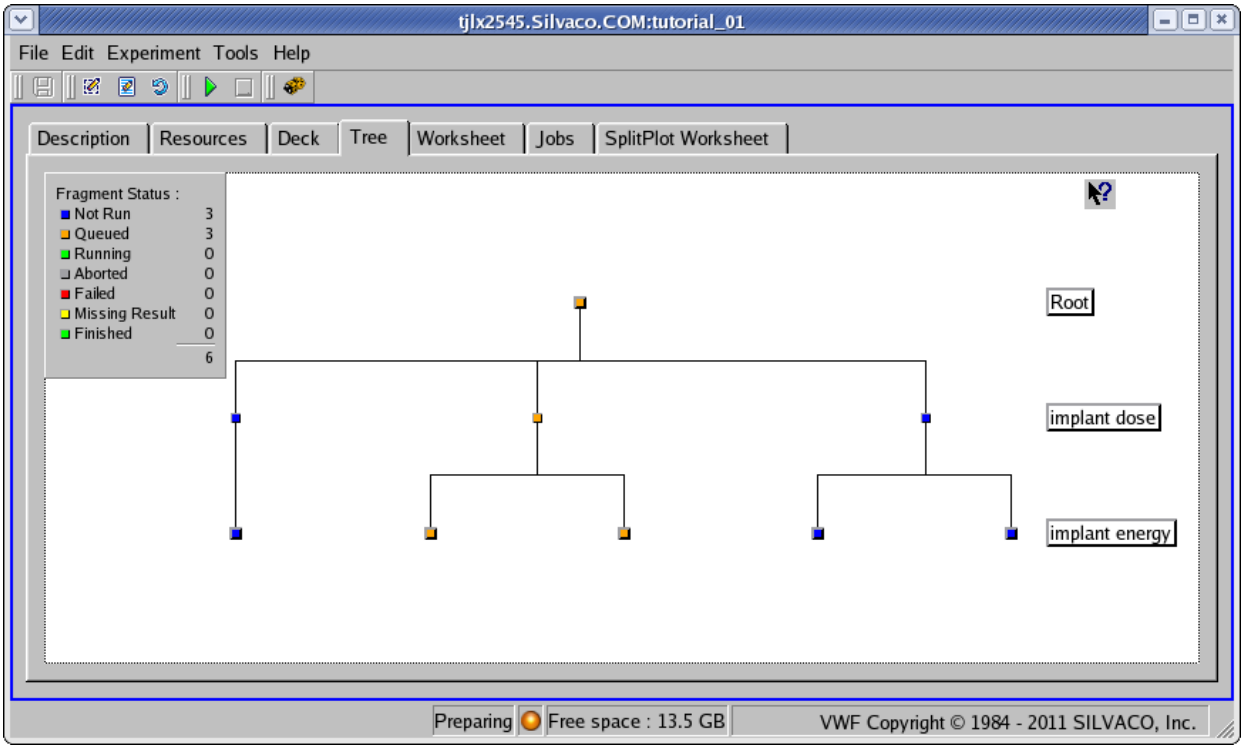


Figure 5-28 Experiment with Queued Branch

When you select the start menu entry, all selected jobs are entered into the job-farming system. This system then decides when and how many jobs are started at any given time. Figure 5-29 displays the situation by selecting **Experiment→Start**. A total of 3 job entries are shown. One job has already been finished, two jobs are just running. The IDs displayed were assigned by the underlying job-farming system and don't necessarily start at 1. When the experiment has unsaved changes, you are prompted to save them before the experiment is actually started.

If you did not add jobs by selecting **Experiment→Queue**, then you are prompted to add all jobs of the tree before the experiment is started. If you click **Cancel** in this case, then nothing happens.

Figure 5-29 displays the situation where two jobs have been selected for execution by the job-farming system. As jobs finish, other jobs will be executed until no more are available.

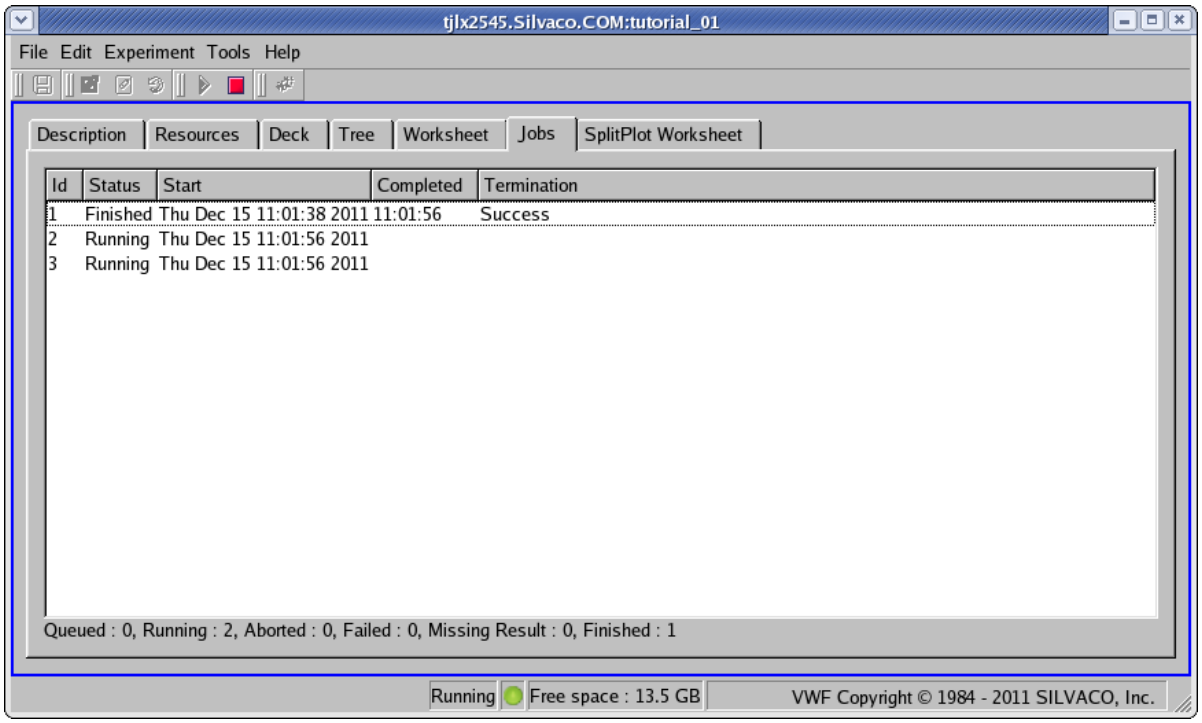

tjlx2545.Silvaco.COM:tutorial_01
File Edit Experiment Tools Help
Description Resources Deck Tree Worksheet Jobs SplitPlot Worksheet
Id Status Start Completed Termination
1 Finished Thu Dec 15 11:01:38 2011 11:01:56 Success
2 Running Thu Dec 15 11:01:56 2011
3 Running Thu Dec 15 11:01:56 2011
Queued : 0, Running : 2, Aborted : 0, Failed : 0, Missing Result : 0, Finished : 1
Running
Free space : 13.5 GB
VWF Copyright © 1984 - 2011 SILVACO, Inc.

Figure 5-29 The Experiment After Selecting Experiment→Start

When the experiment has been successfully started, you can observe the status information for every job in the system. You can get this information by navigating to the tree tab. Right-clicking on any node will open the Node Information dialog (see Figure 5-30).

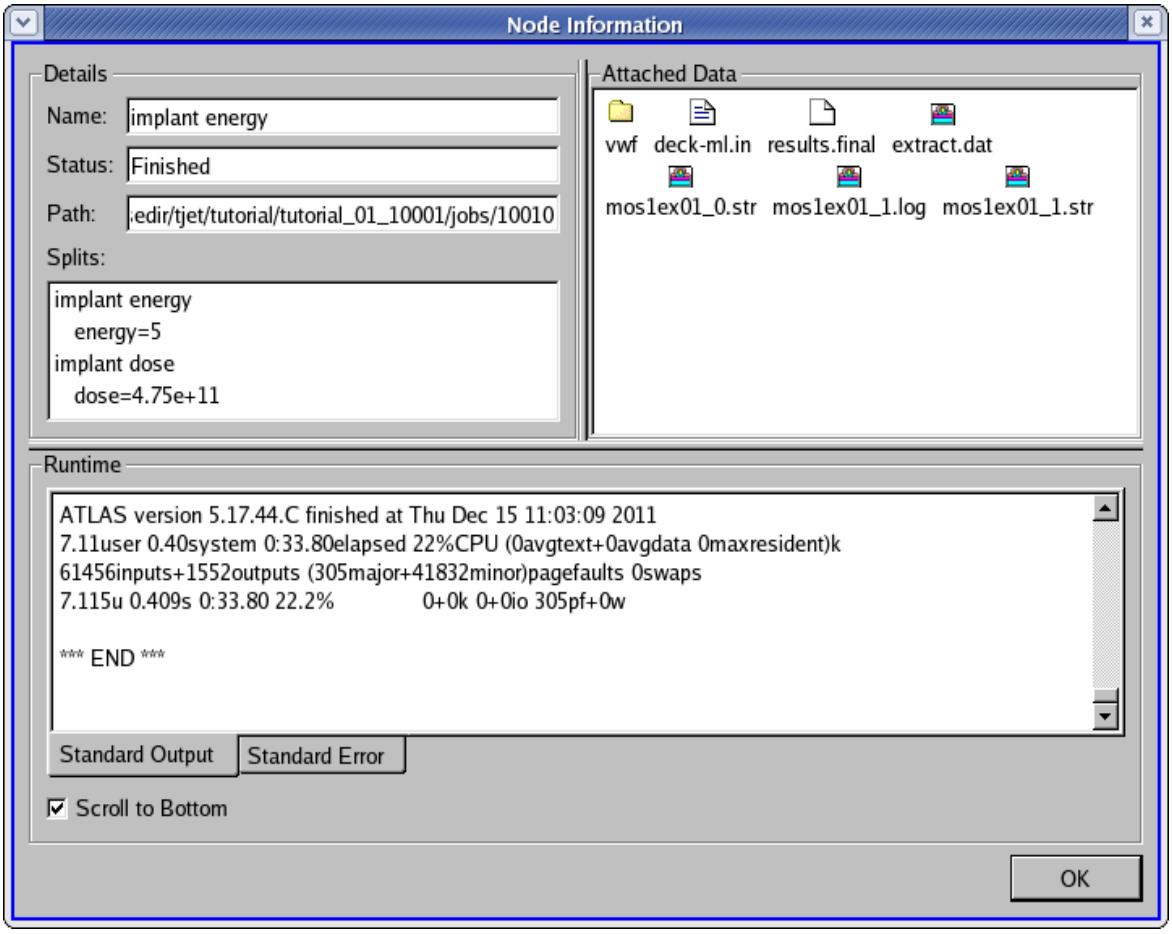


Figure 5-30 Node Information Dialog

The displayed node information consists of several parts. The **Details** pane depicts values of parameters as they are used in the underlying simulation. The **Attached Data** pane contains a list of all files, which were created during the simulation. By double-clicking one of the files, the associated application will open. The **Runtime** pane displays runtime standard output and standard error of the simulation. This will only contain text if the simulation has already been started (or finished). When the **Scroll to bottom** box at the bottom right corner is activated, the pane will scroll down to the bottom as new data arrives.

The **Worksheet** view changes during simulation. The extracted values appear when jobs are finished. Once the whole experiment is finished, entries for all but simulations, which have not been run or did not produce any results, are available as shown (Figure 5-31).

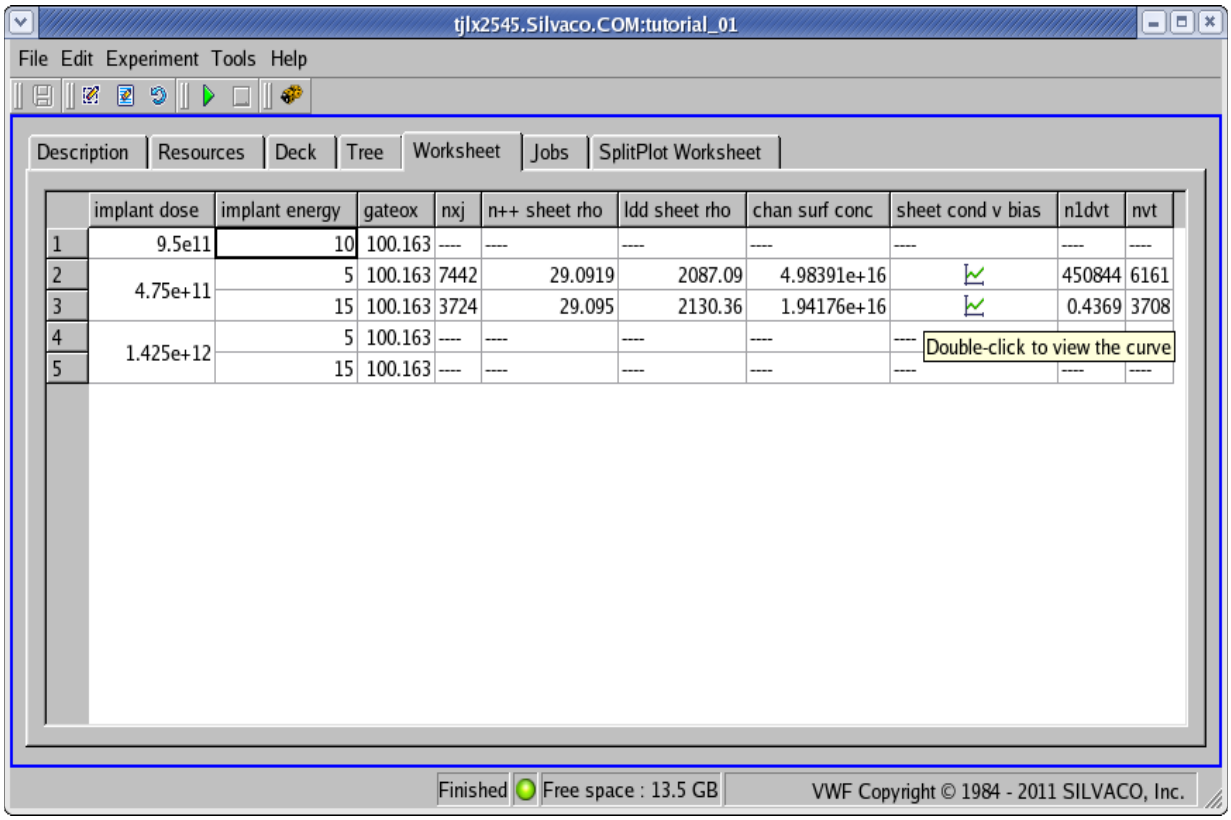

tjlx2545.Silvaco.COM:tutorial_01
File Edit Experiment Tools Help
Description Resources Deck Tree Worksheet Jobs SplitPlot Worksheet
implant dose | implant energy | gateox | nxj | n++ sheet rho | ldd sheet rho | chan surf conc | sheet cond v bias | n1dvt | nvt
1 | 9.5e11 | 10 | 100.163 | ---- | ---- | ---- | ---- | ---- | ---- | ----
2 | 4.75e11 | 5 | 100.163 | 7442 | 29.0919 | 2087.09 | 4.98391e+16 | 450844 | 6161
3 | | 15 | 100.163 | 3724 | 29.095 | 2130.36 | 1.94176e+16 | 0.4369 | 3708
4 | 1.425e+12 | 5 | 100.163 | ---- | ---- | ---- | ---- | ---- | ---- | ----
5 | | 15 | 100.163 | ---- | ---- | ---- | ---- | ---- | ---- | ----
Double-click to view the curve
Finished
Free space : 13.5 GB
VWF Copyright © 1984 - 2011 SILVACO, Inc.

Figure 5-31 Generated Responses

Right-clicking on a finished node in the tree and selecting **Plot→All** will start TonyPlot on your computer and display the structure and data files (curves) that were generated during the simulation (Figure 5-32).

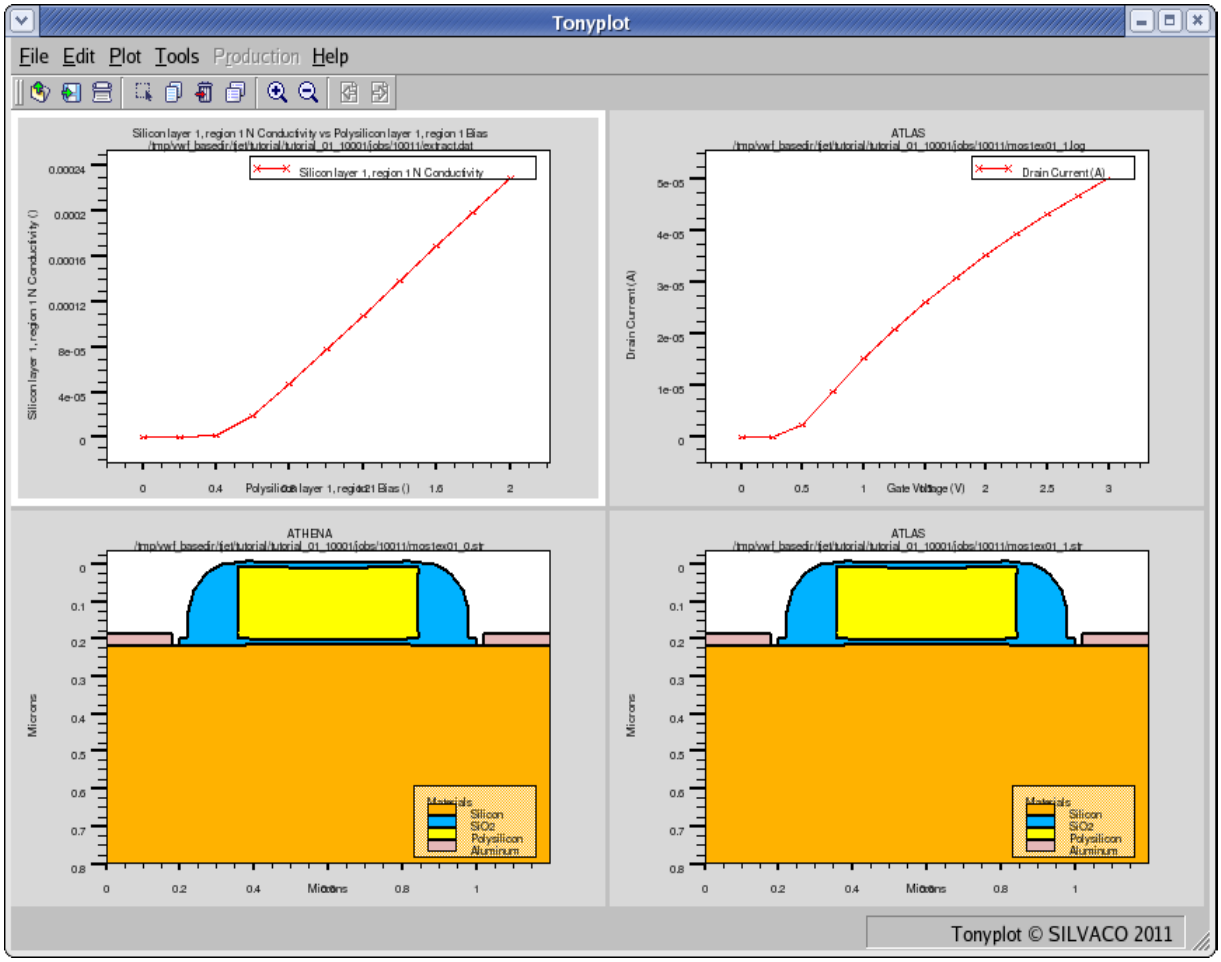


Figure 5-32 Viewing Result Files

5.6 Exporting Data From VWF

An experiment can be exported into a file and imported into another database. This is useful if experiments are shared among different users or databases. For instance, when a customer requests help on a particular problem and sends in the experiment, an AE can then import it into one of Silvaco's databases, examine the problem, and provide the required assistance. To export an experiment into a file, select **File→Export** in the Experiment Window. A dialog box will prompt you to select a file (Figure 5-33) and what kind of information you want to export. The minimum to export is the experiment definition (**Experiment**). This includes the deck and the split information but not the worksheet data. On top of the experiment, you can decide to also include **Resources**, **Results**, and **Result Files**. If you want to later rerun the example, you need to include **Resources**. To add worksheet data to the exported file you have to click **Results**. Finally, click **Result Files** if you also want to export generated structures and runtime output.

Note: Adding **Result Files** may considerably increase both the size of the resulting export file and the time for the export to complete..

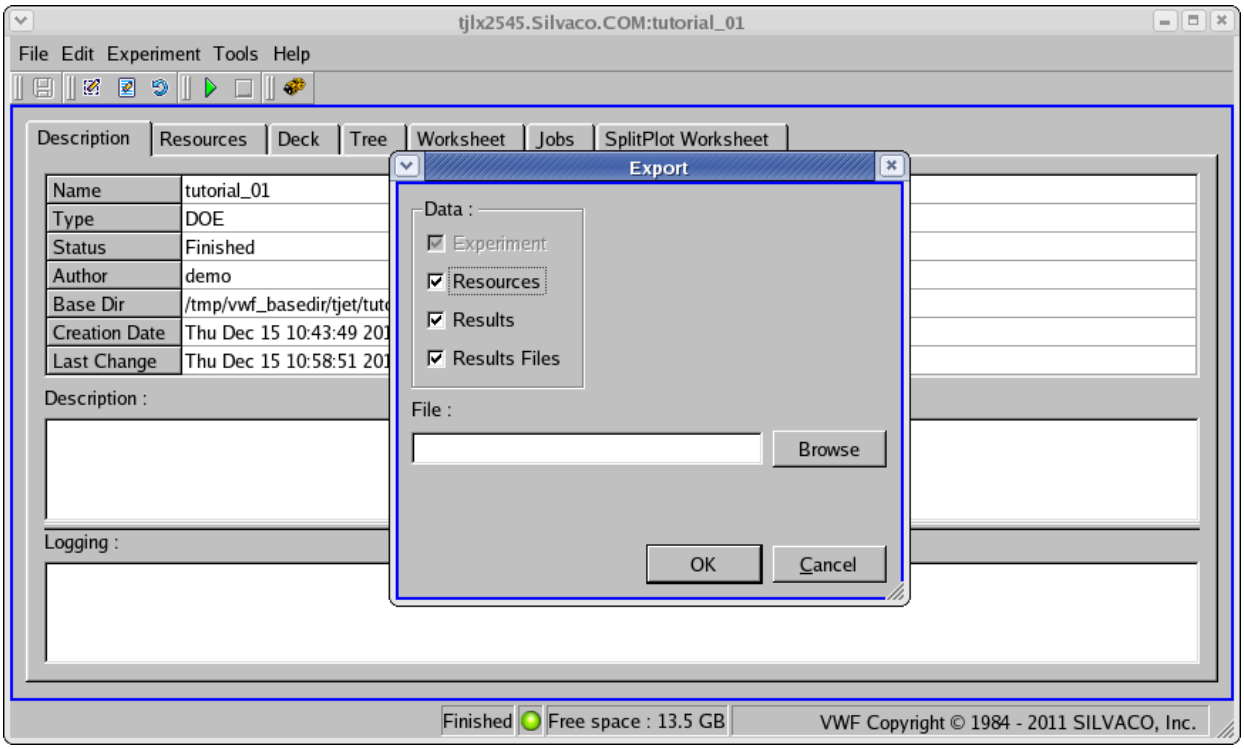


Figure 5-33 Export Experiment

5.7 Exporting Worksheet

Apart from the export options displayed above, it can also be chosen to export just the worksheet data into a comma separated values (CSV) file. This is useful if an external tool (e.g., Excel) is used for further investigations on the computed results. To export the worksheet, select **File→Export Worksheet** in the Experiment Window (Figure 5-34). This will open a dialog box, which will prompt you to select a file.

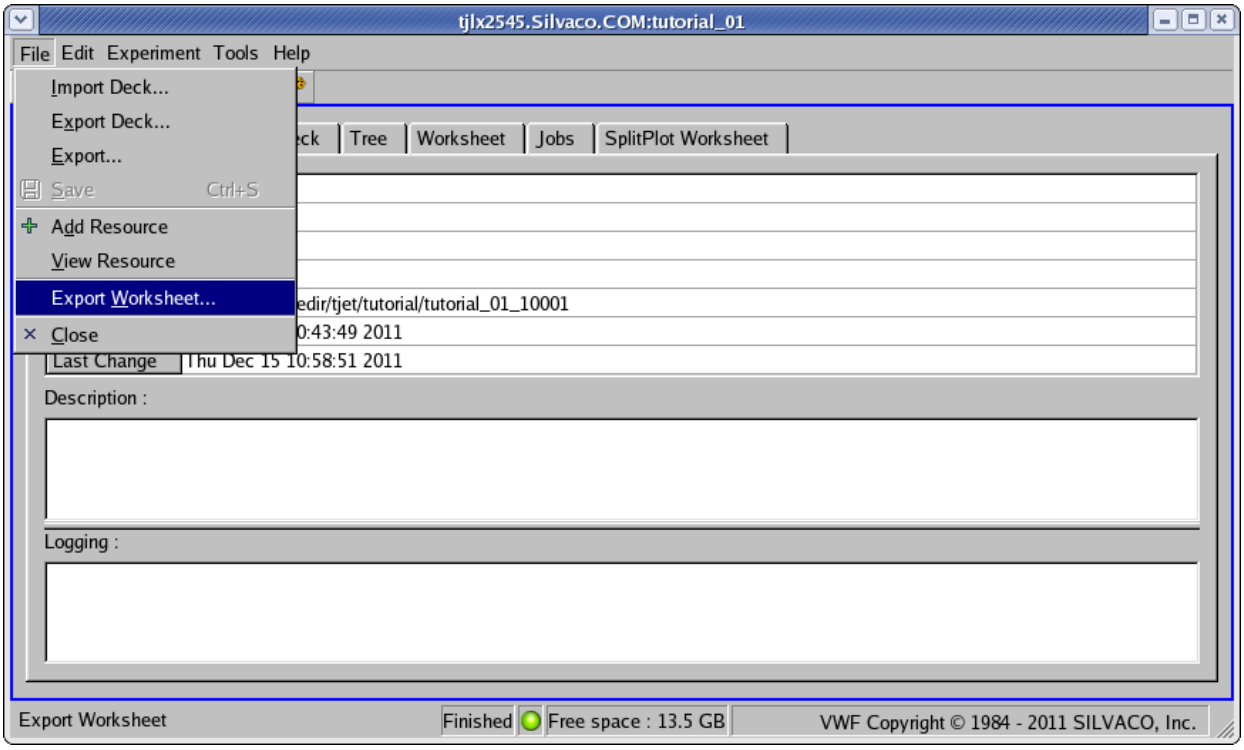


Figure 5-34 Export Worksheet into CSV

5.8 Exporting Optimization Results

The dialog to export results from an optimization run looks different to a DOE run. Figure 5-35 shows how the data can be exported. Figure 5-36 shows the dialog to select a filename.

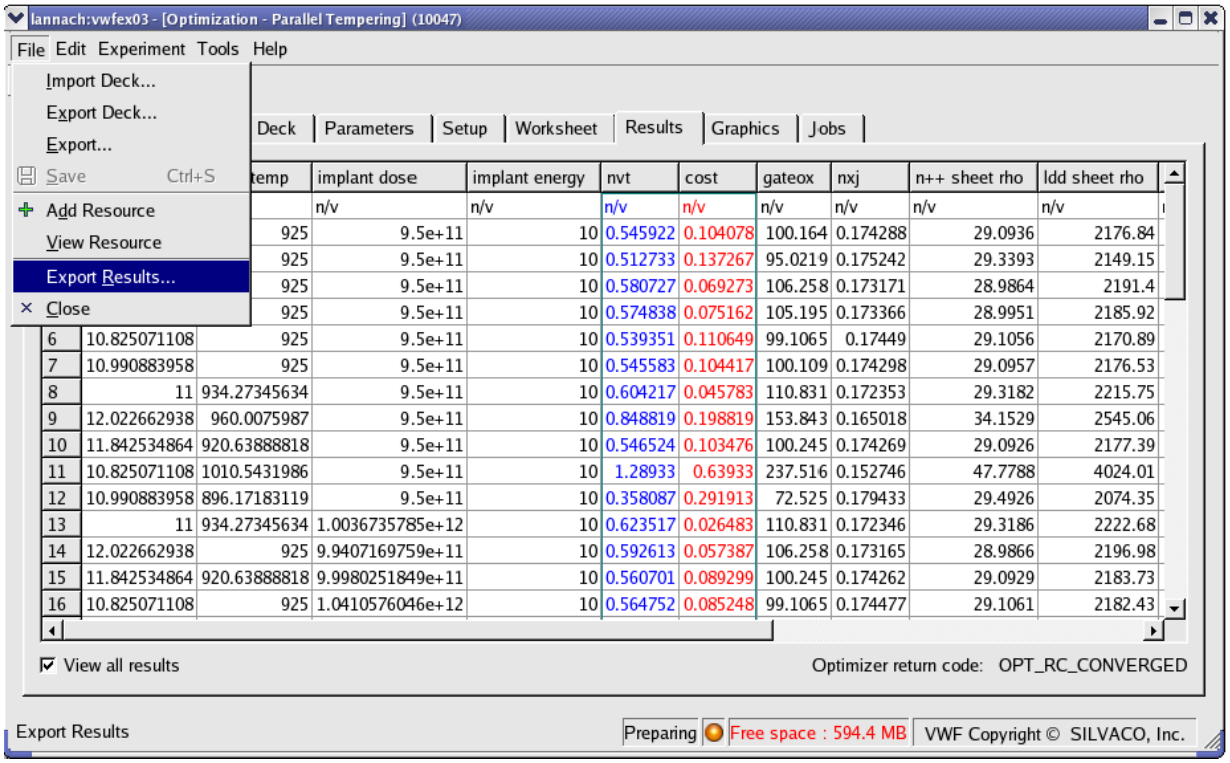


Figure 5-35 Exporting Results of an Optimization Experiment

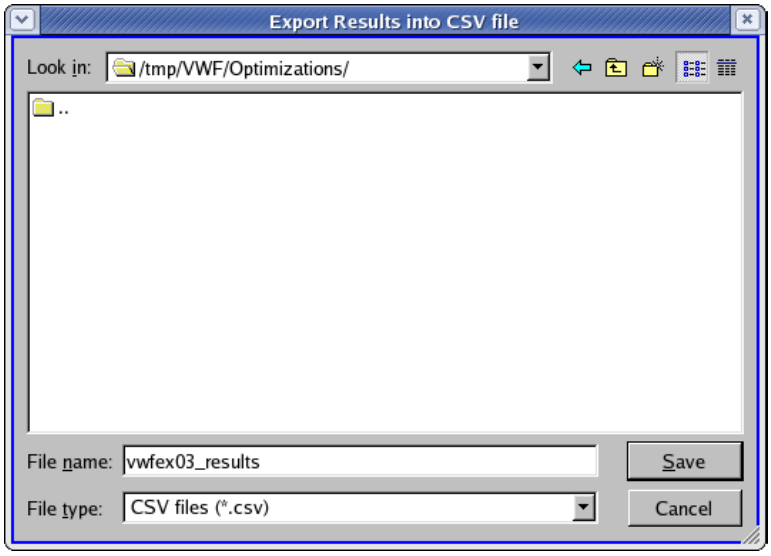


Figure 5-36 Selecting Files for Results Export

5.9 Importing Data into VWF

Data from previously exported files can be imported into the database again. Only full exports (created through the **File→Export** command) can be imported. Worksheet data as created by **File→Export Worksheet** cannot be imported into VWF as an experiment. To import data, select **File→Import→File** or **File→Import→Batch** (see Figure 5-37).

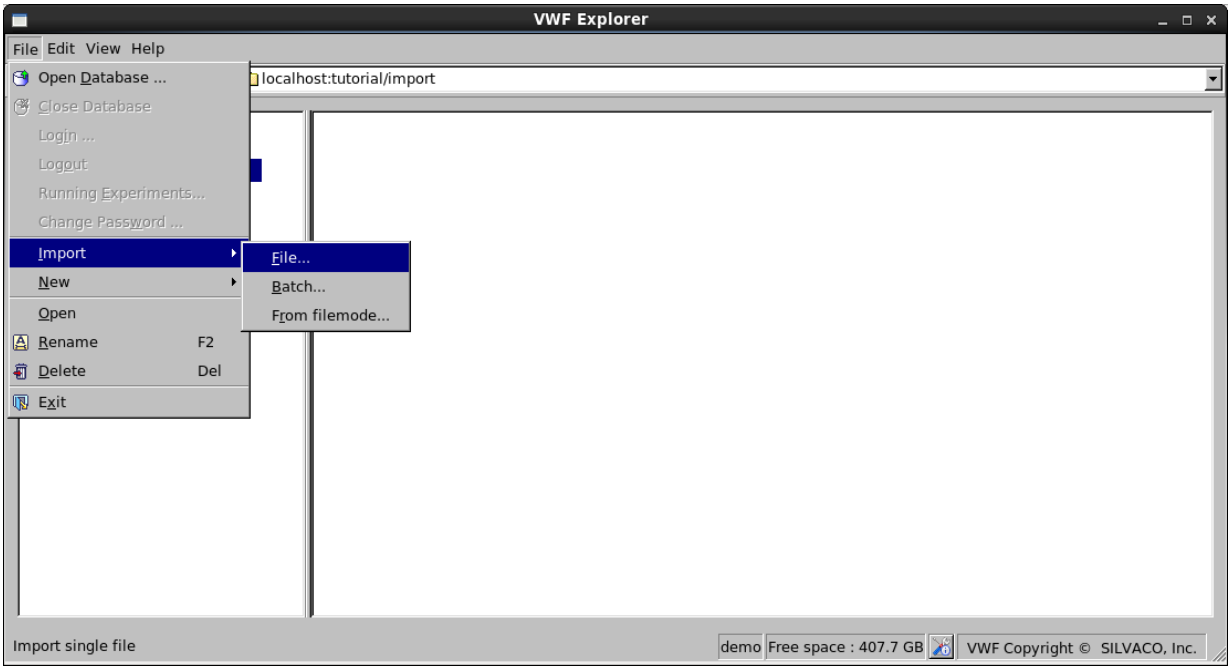


Figure 5-37 File Import Menu Entries

You can use both **File** and **Batch** options to import previously exported experiments. The **File** option displays a file selector dialog box, which allows you to select a single file. The **Batch** option displays a dialog (Figure 5-38) where you can select an arbitrary number of experiments for import.

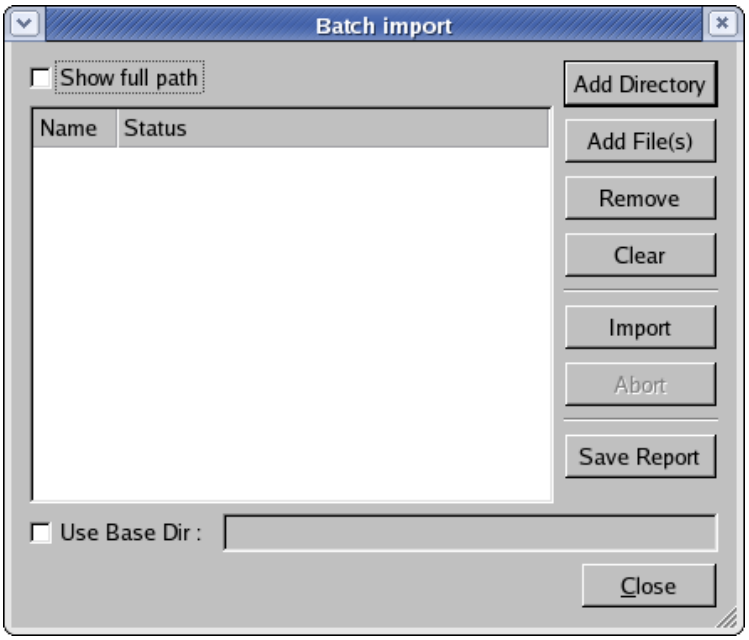


Figure 5-38 Batch Import Dialog

The idea of the batch option is to allow importing several experiments at a time. You need to first compile a list of experiments to import. There are several ways to populate the list. You can either add all experiments contained in a directory by clicking on the **Add Directory** button, or you can add individual experiments by clicking on the **Add File(s)** button. Here, you can select several experiments in the shown file selector.

Experiments can be removed from the list using the **Remove** button. The whole list can be emptied by using the **Clear** Button.

When you are satisfied with the selection, click on the **Import** button to start the import procedure (Figure 5-39).

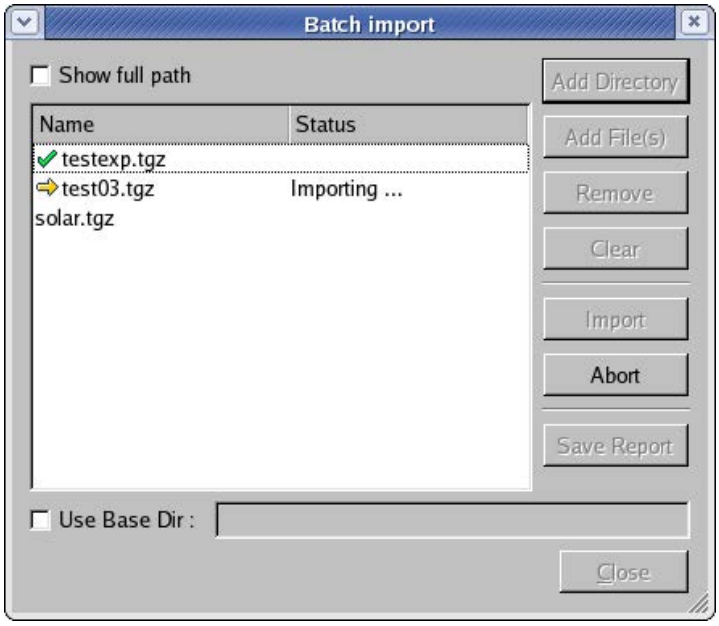


Figure 5-39 Batch Import Processing

You can interrupt the batch process by clicking on the **Abort** button.

If an error occurs during any of the import operations, a short message about the cause of the problem is shown in the status field of the window.

Note: This will only prevent remaining experiments to be imported. The currently imported experiment is not interrupted or removed.

5.10 Importing Worksheet Data to Define a DOE

VWF offers a mechanism that allows you to define an experiment based on data available in a comma separated values (CSV) file. This feature is useful in case you want to use an externally created DOE on an experiment and want to run that experiment from within VWF (e.g., to utilize the grid computing facilities). Please see also the scripting facility, which allows you to define custom DOE designs by means of a JavaScript script (see Section 7.2 “Defining Custom DOE Strategies” and Figure 3-55).

In order to use this mechanism, you must first create an empty experiment and define split variables in this experiment. You should have a tree as the one shown in Figure 5-40. Make sure to not use one of the VWF designs and do not create splits manually. Then, you create a CSV file using your DOE tool (or manually). The CSV file must contain the same amount of split variables and variables need to have the exact same names as the ones that you defined in VWF.

Note: You can first export the empty worksheet from VWF to get the structure of the CSV file.

You can then select the **Edit→Import Worksheet** functionality as shown in Figure 5-41. Figure 5-42 displays the dialog to select a file for import.

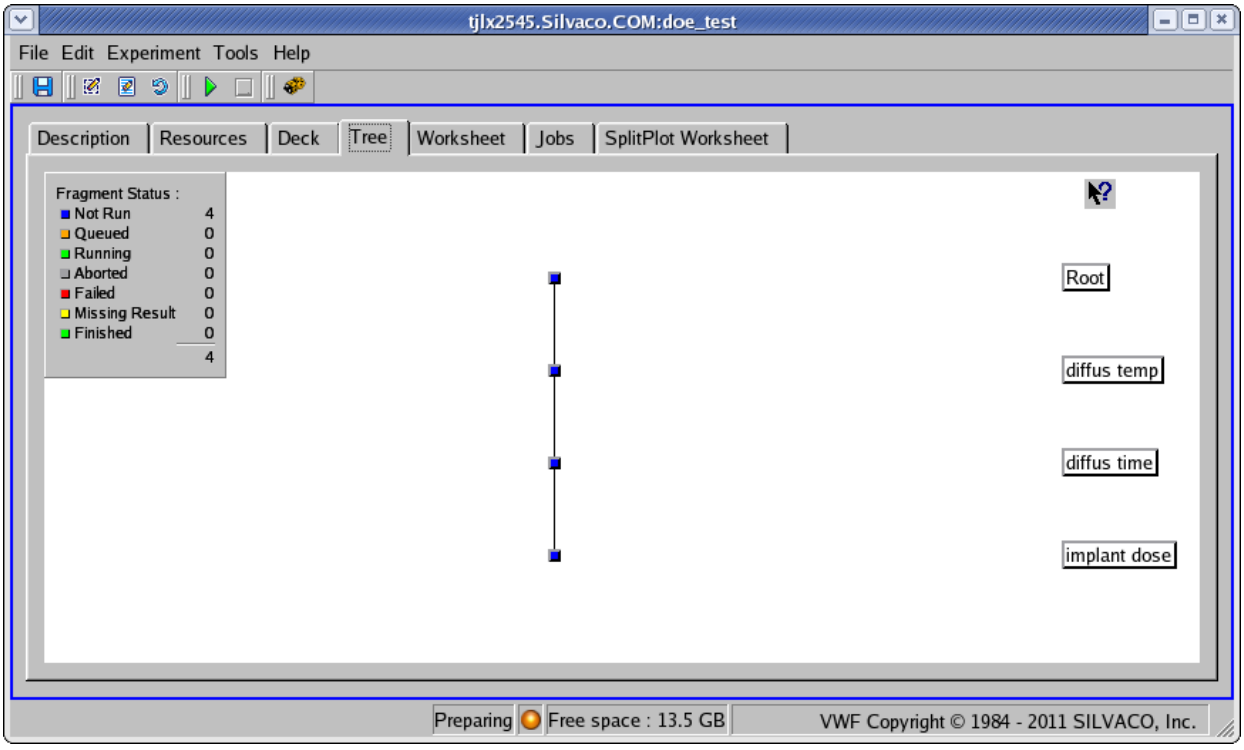


Figure 5-40 Tree of Experiment with only Split Variables Defined

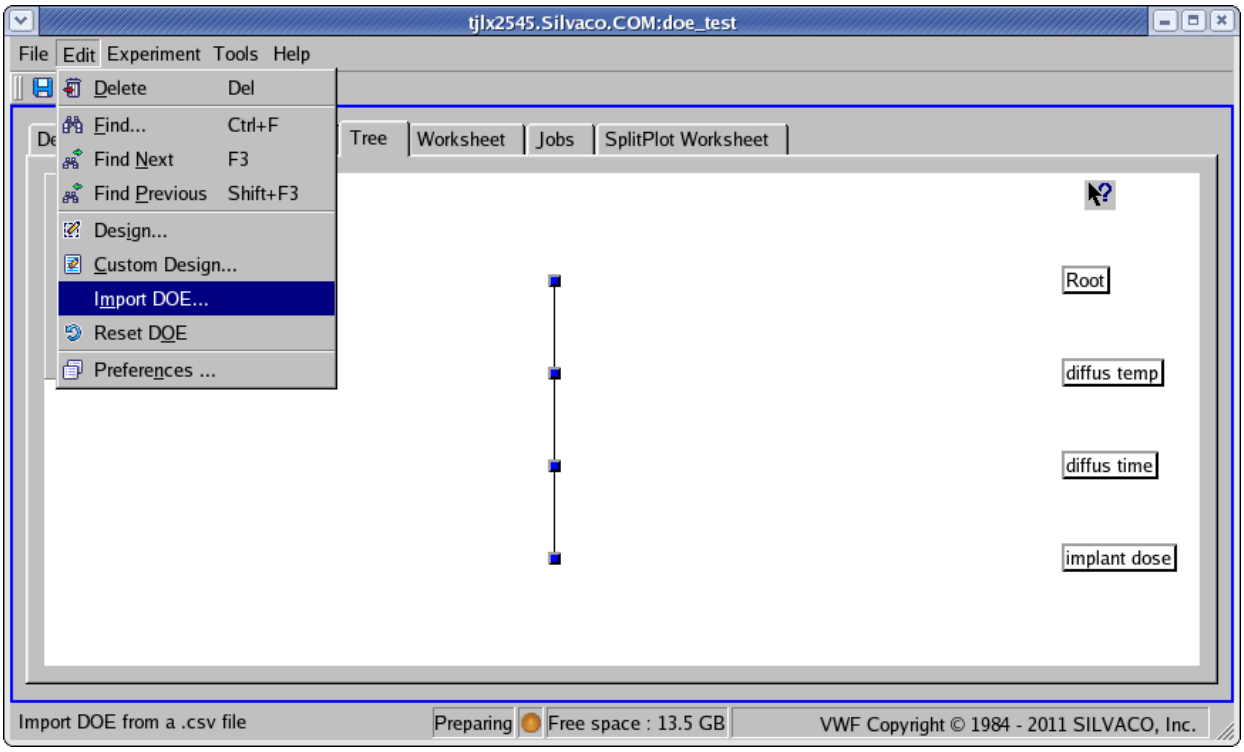


Figure 5-41 Import an External DOE into VWF

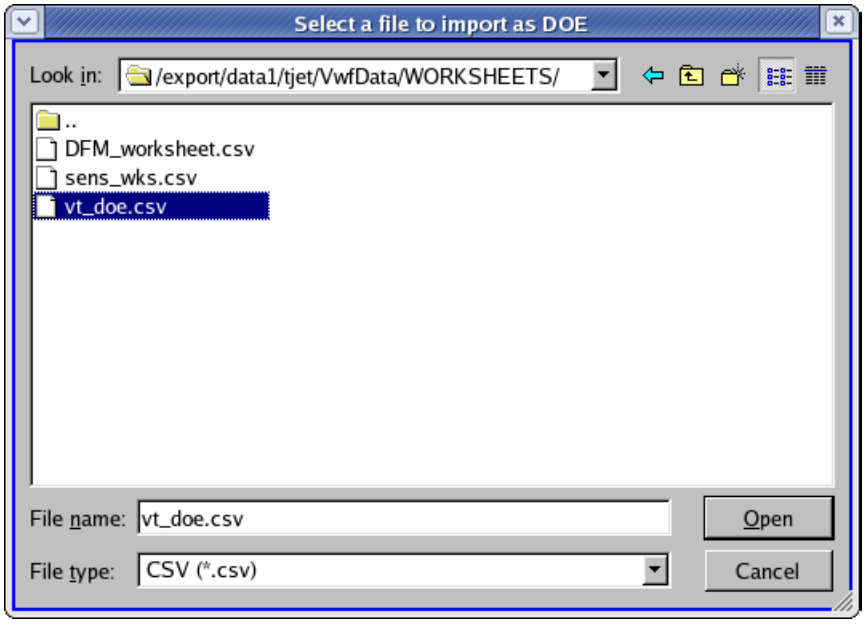


Figure 5-42 Dialog to Select CSV File

Before the import function can be completed, a number of checks are performed and you are informed of possible errors, such as a parameter mismatch. Figure 5-43 depicts the error case where no split variables have been defined in your VWF experiment. If this happens, please **OK** the dialog and go back to the editor pane to define split variables.

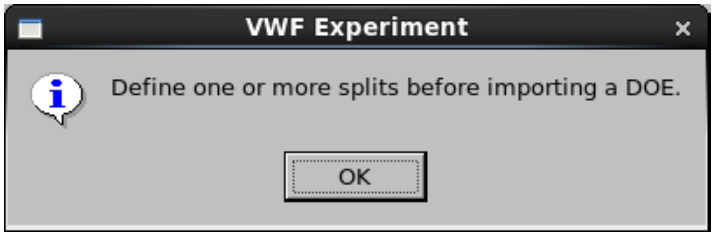


Figure 5-43 No splits Have Been Defined for DOE Import

Figure 5-44 shows the case where the split variable names in the experiment are different from those in the experiment as they are in the CSV file. VWF allows you to ignore this error and continue, but it is advisable to check where the cause of the problem is. If you decide to ignore the error, then VWF assigns split parameters as they occur in the file. The first found parameter in the CSV file is assigned to the first found parameter in the deck of the experiment in VWF.

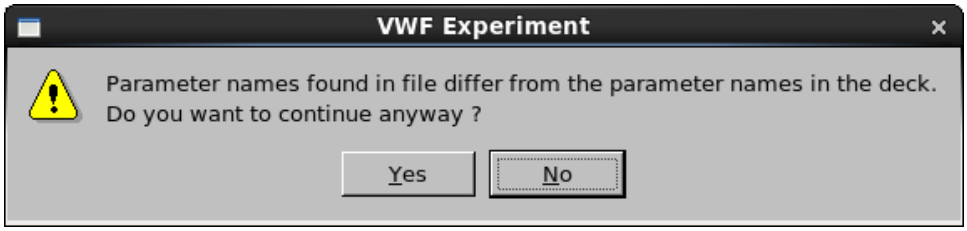

VWF Experiment
Parameter names found in file differ from the parameter names in the deck.
Do you want to continue anyway ?
Yes
No

Figure 5-44 Inconsistency with Variable Names

Figure 5-45 depicts the case where the number of split variables in your CSV file differs from the number of split variables in the experiment. VWF offers to ignore this error and take over only the amount of variables for which corresponding parameters are existing in VWF. This only works if there are more parameters in the CSV file as there are parameters in the experiment. It is advisable to check the cause of this inconsistency.

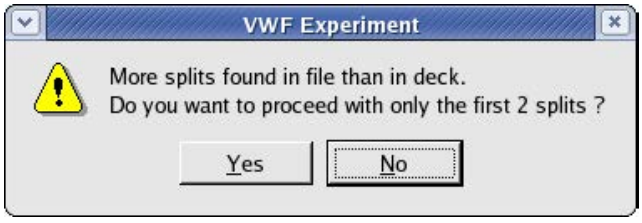


Figure 5-45 Inconsistent Number of Splits

Figure 5-46 displays the populated tree after a successful import.

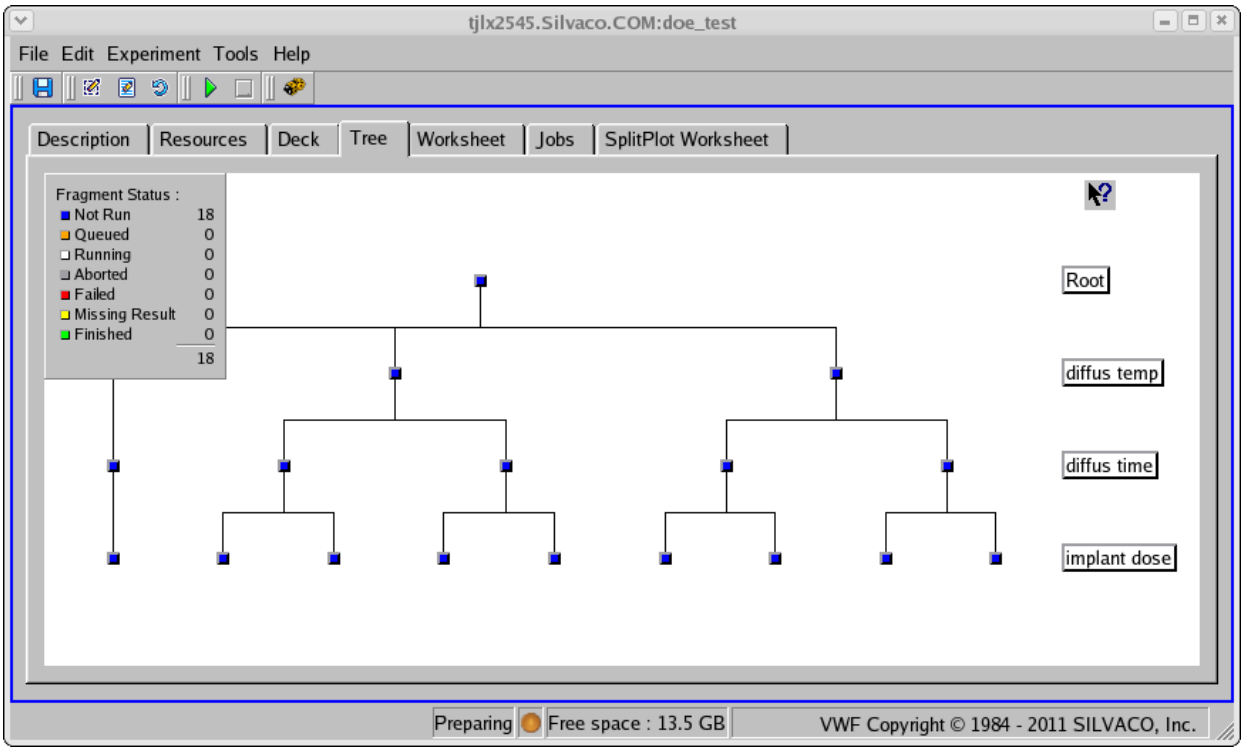


Figure 5-46 Tree Resulting from CSV Imported DOE

5.11 Sending Worksheet to SPAYN

SPAYN is used for Post-processing to perform Data Modeling such as Regression analysis, Correlation analysis, Multi-dimensional data analysis, Histogram, and Scattergram plots. VWF will start a single instance of SPAYN where it sends the worksheet data to.

There are two ways of invoking the SPAYN interface from an experiment window. The first way is to select **Tools→Spayn** (Figure 5-47). The second way of invoking SPAYN is by using the **Tools→Sensitivity Analysis** entry. This method will be described further down. After selecting **Tools→Spayn**, the Send Worksheet To Spayn dialog will appear (Figure 5-48).

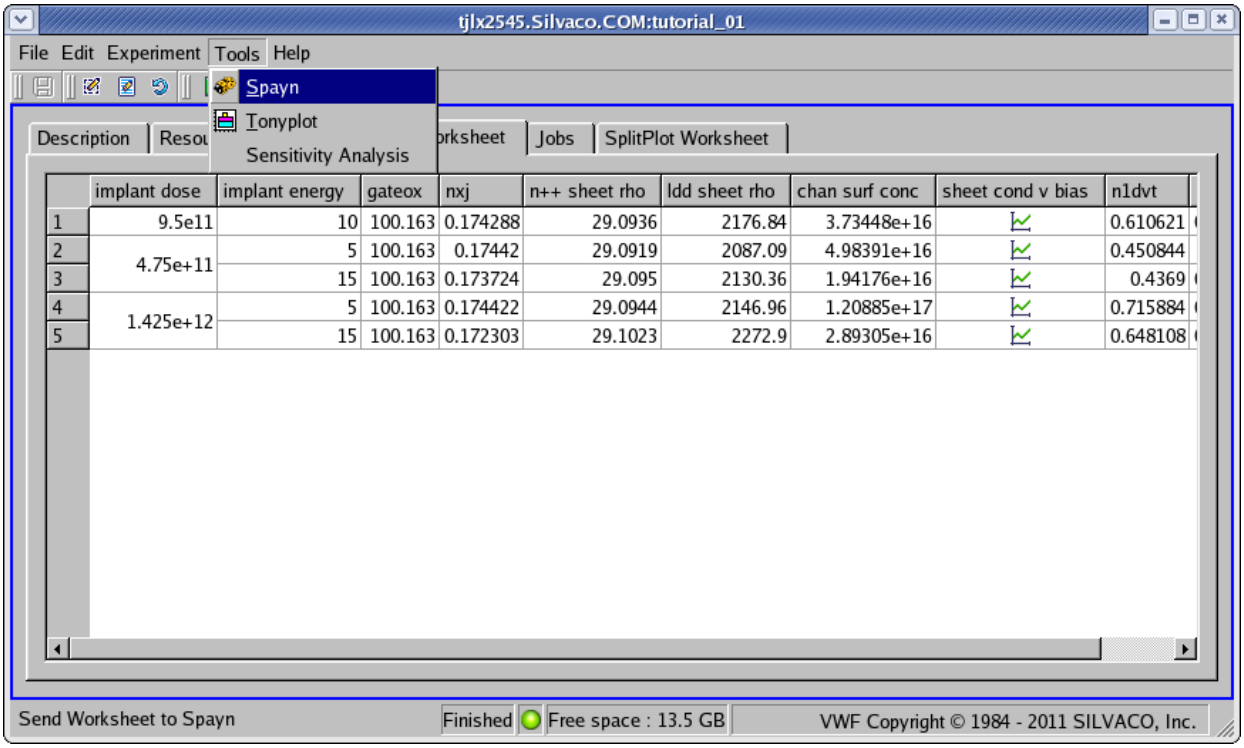


Figure 5-47 Tools Menu

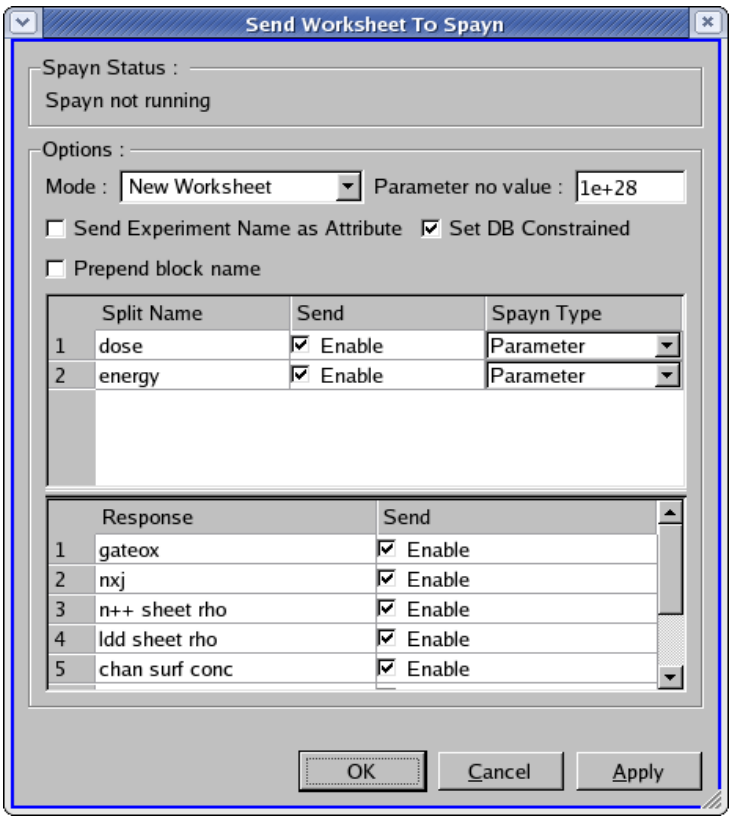


Figure 5-48 Send Worksheet To Spayn dialog

To send the worksheet to SPAYN, you must specify in VWF whether the data will create a blank worksheet or append to the current worksheet in SPAYN. In the latter case, some conditions may apply (see below). You must specify which value to use when a worksheet cell is empty. Specify which **Split variable** to send and their **Spayn Type** (**Attribute** or **Parameter**) and which **Reponse** to send. SPAYN will not be running if this is the first time data will be sent to it. The **Spayn Status** box provides information whether SPAYN has already been started and about the current status.

Specify which mode to use: **New Worksheet** or **Append to Worksheet**. **New Worksheet** will delete a previously created SPAYN worksheet. To successfully append data to a previously created worksheet, the number of **Attributes** and **Parameters** of the new data set must exactly match.

If a worksheet doesn't contain a value, the value specified in the field next to **Parameter no value** is used.

In the case when appending from different experiments, experiment name can be prepend to each sample as attribute. To do this, check **Send Experiment Name as Attribute**.

You can send **Split variables** to **Spayn as Attributes** (by default) or **Parameters** individually. You can prevent **Split Variable** from being sent to SPAYN by unchecking **Enable** in the table.

The popup menu on the Split Variable table provides shortcuts to enable/disable all items to send and to switch from **Attributes** or **Parameters**.

You can send **Response** to SPAYN as **Parameters** only. You can prevent **Response** from being sent to SPAYN by unchecking **Enable** in the table.

The popup menu on the Response table provides shortcuts to enable/disable all items to send. Once options are set, you can click on **OK**/**Apply** to send worksheet to SPAYN. If SPAYN is not running, VWF will start it. This operation may take some seconds, according to the network load. A message at the bottom of dialog notify you about the current operation. When SPAYN is started, data will be sent and a message at bottom of dialog will be updated.If an error occur, a message box is shown with an explanation like Figure 5-49.

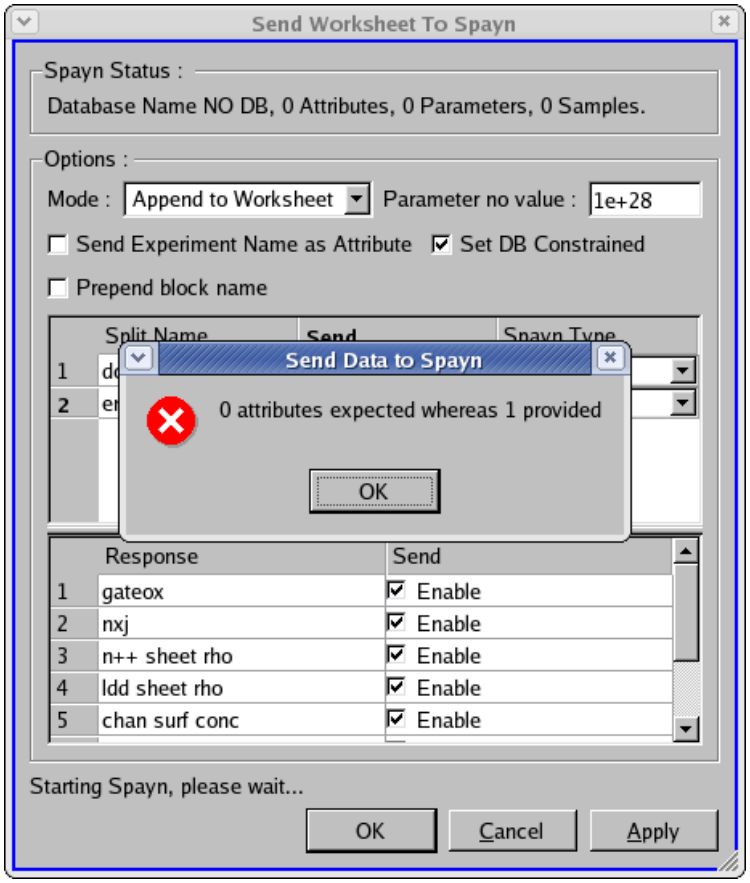


Figure 5-49 Attributes count mismatch

The **Spayn Status** box is updated with the latest SPAYN database information: **Number of Attributes**, **Number of Parameters**, and **Samples count**.

When you start SPAYN this way, it automatically performs a full attribute search and a constrained parameter search with all parameters selected. Full details on attributes and parameter searching are presented in Chapter 4 of SPAYN User's Manual.

The second way of invoking SPAYN is from a **Sensitivity Analysis** experiment. You can create such an experiment by choosing **Sensitivity** in the Experiment Design dialog. Then, you select all the variables you want to vary and you choose the percentage of variation. Once this is done and validated, your experiment has a specialized Sensitivity Analysis Tree and can be run. When the experiment has finished, select **Tools→Sensitivity Analysis** from the **Experiment** menu.

For full SPAYN capability and feature description, please see SPAYN User's Manual.

5.12 VWF File Mode

In addition to allowing access to a database, VWF also allows to store experiments in single files. This mode was introduced to relieve you from installing a database and to be able to quickly view exported experiments. It can be invoked by adding the `-filemode` option on the command line. For example:

```
vwf -filemode
```

This will open the following window (see Figure 5-50).

Figure 5-50 VWF File Mode Window

At the bottom of the dialog, you can get access to the Preferences pane using the preferences button. Next to the **Preferences** button, there is the "tool version" ( ) button. This button will display version numbers of tools as selected in preferences. If all tools are set to use the default version, then this button is inactive (grayed).

Figure 5-51 shows that version 2.12.0.R of Spayn and version 4.0.0.C of DeckBuild are used respectively. For all other tools, default versions are being used.

Please refer to Chapter 4 "Customizing VWF – Preferences Panel" for details on how to change the tool versions.

Figure 5-51 Tool Versions

The dialog allows you to chose among three ways of opening a file. To open an existing experiment, use the **Browse** button to display a file selector box and to select the experiment file to open. When you select a file, the **OK** button will become enabled and allows to confirm and load the selected file. **Create experiment** (Figure 5-52) allows you to create a new experiment. You need to define a name and a type.

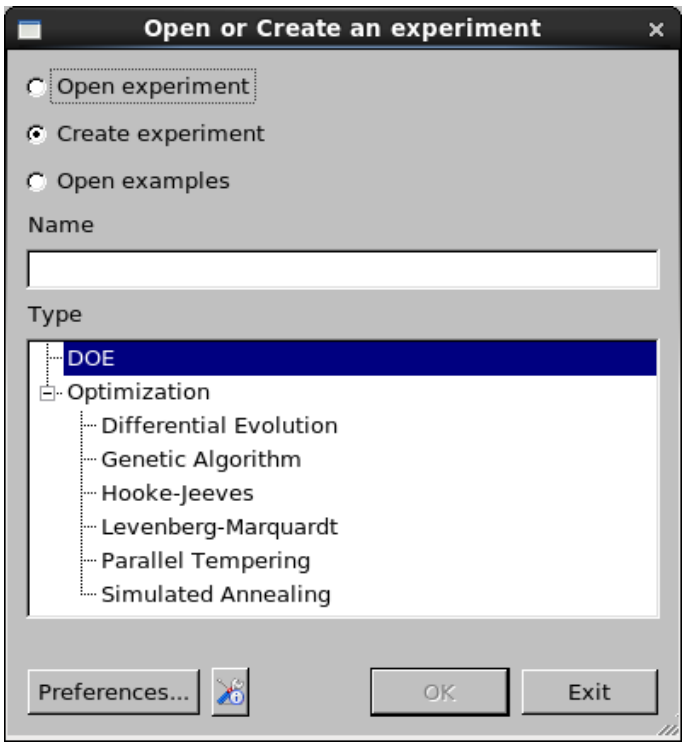


Figure 5-52 VWF File Mode Create Experiment

Open examples (Figure 5-53) allows to open files from the example section. As experiment files also contain runtime output (results) and example files are normally stored in a read-only location, the selected example needs to be copied to a writable location first. The lower part of the dialog allows you to select a location to copy the file to. The default is a directory called `vwf_examples` in your home directory.

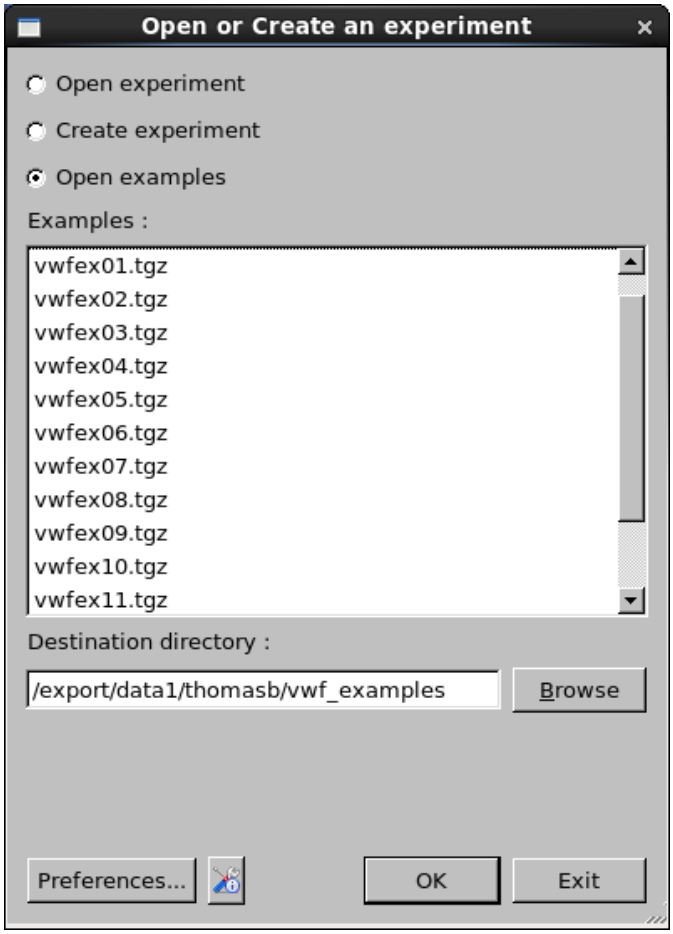


Figure 5-53 VWF File Mode Open Examples

As soon an example is highlighted, the description of the example is shown (Figure 5-54).

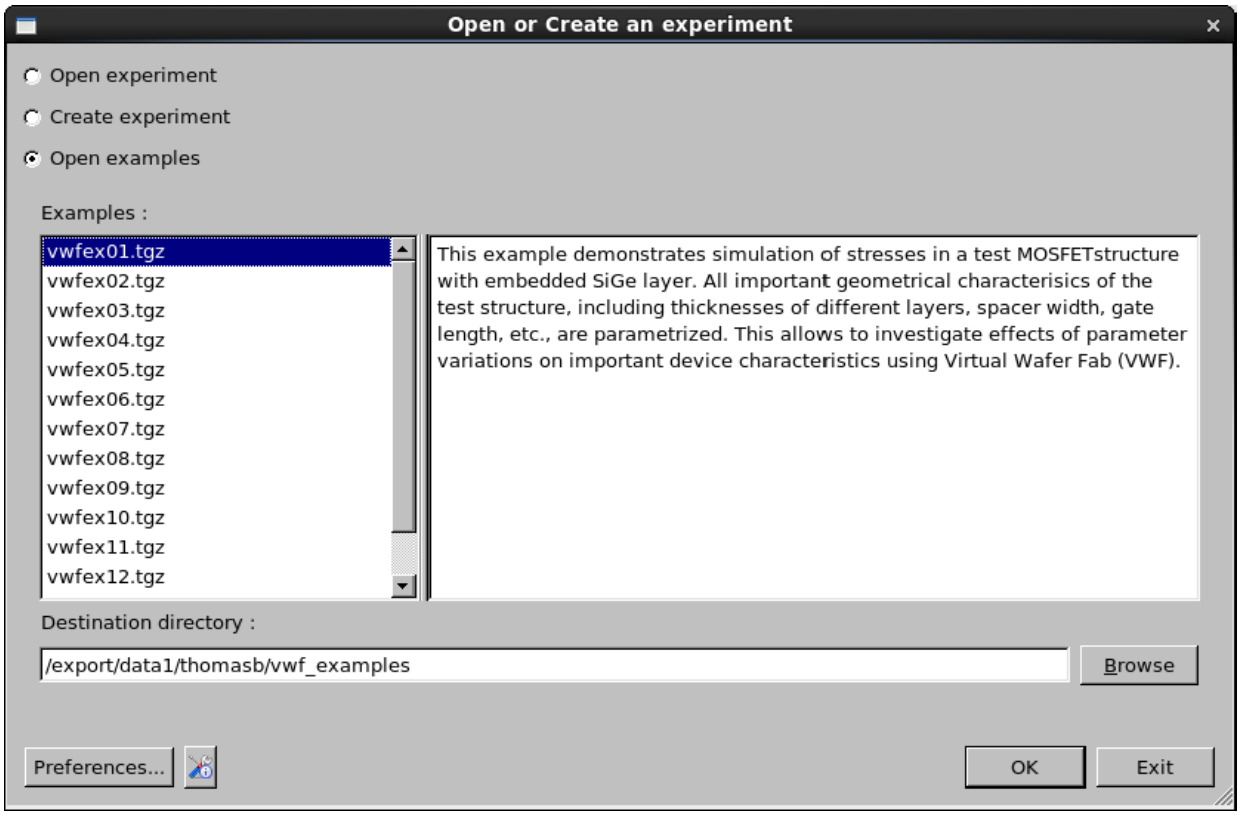


Figure 5-54 Examples with Descriptions

5.13 Using VWF to Run SmartSpice Simulations

The following example shows how to run a SmartSpice analysis in VWF. You must create and test a working schematic or netlist, free of any simulation errors, before using VWF to run SmartSpice simulations.

5.13.1 Preparing the Circuit

A simple comparator circuit is prepared using the Gateway Schematic Editor (Figure 5-55)

In this case, three split parameters are defined using `.PARAM` (Figure 5-56).

- Power Voltage: `VDD`
- Temperature: `tempval`
- Output load capacitor : `capval`

The example demonstrates a SPICE model library and the use of analysis and measure statements in the control card (Figure 5-57).

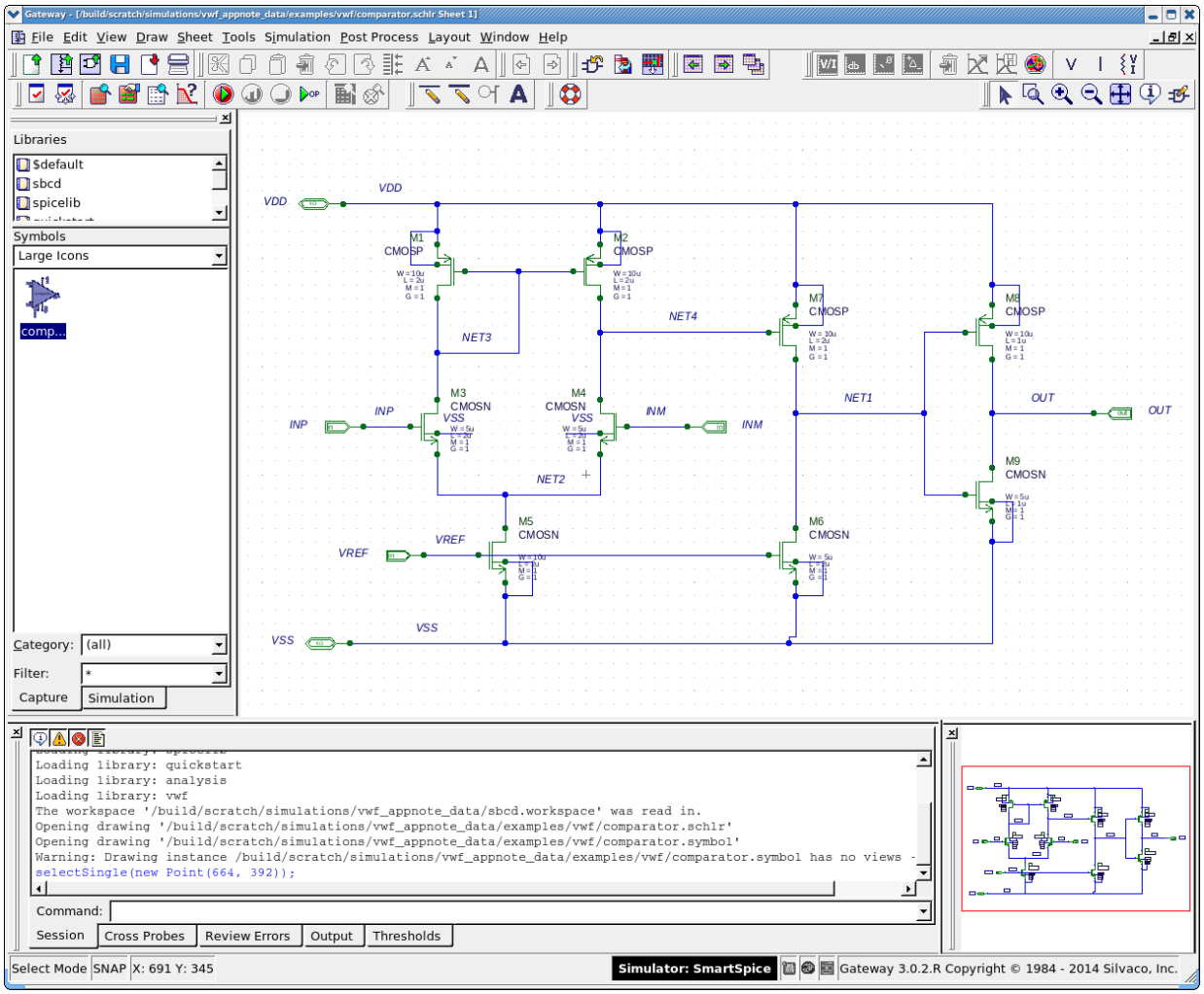


Figure 5-55 Creating a schematic in Gateway

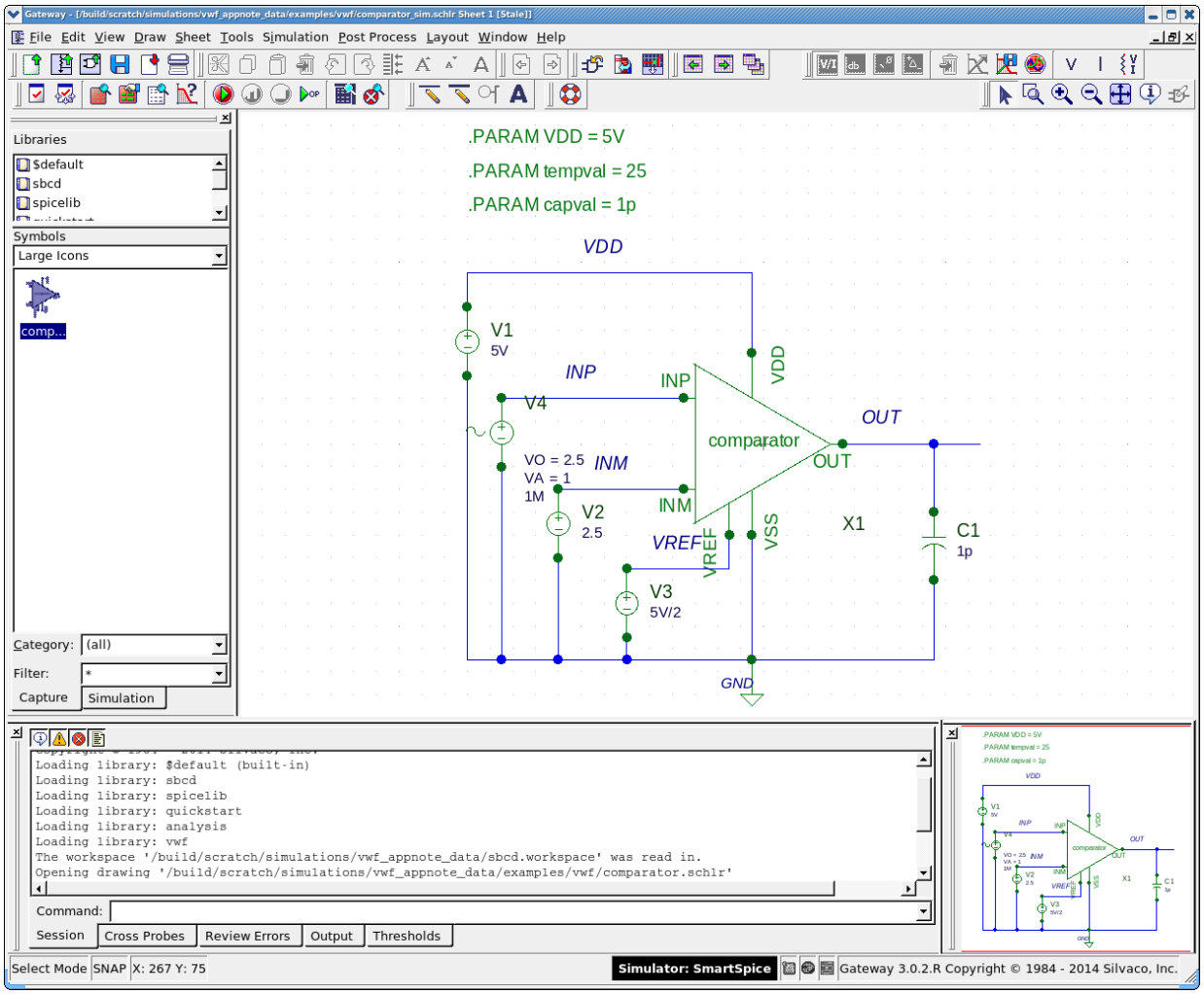


Figure 5-56 PARAM setup

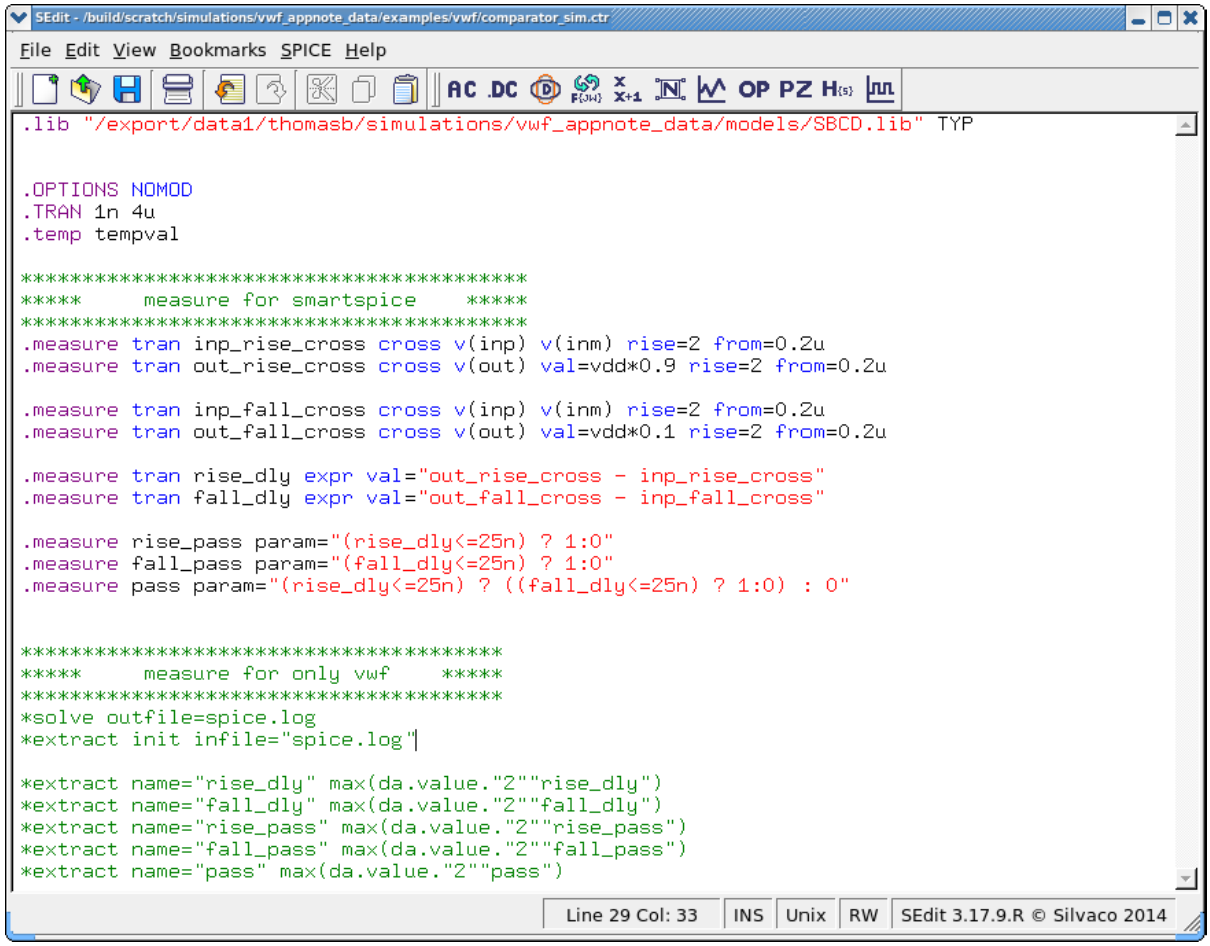

SEdit - /build/scratch/simulations/vwf_appnote_data/examples/vwf/comparator_sim.ctr
File Edit View Bookmarks SPICE Help
.lib "/export/data1/thomasb/simulations/vwf_appnote_data/models/SBCD.lib" TYP
.OPTIONS NOMOD
.TRAN 1n 4u
.temp tempval
****
***** measure for smartspice *****
****
.measure tran inp_rise_cross cross v(inp) v(inm) rise=2 from=0.2u
.measure tran out_rise_cross cross v(out) val=vdd*0.9 rise=2 from=0.2u
.measure tran inp_fall_cross cross v(inp) v(inm) rise=2 from=0.2u
.measure tran out_fall_cross cross v(out) val=vdd*0.1 rise=2 from=0.2u
.measure tran rise_dly expr val="out_rise_cross - inp_rise_cross"
.measure tran fall_dly expr val="out_fall_cross - inp_fall_cross"
.measure rise_pass param="(rise_dly<=25n) ? 1:0"
.measure fall_pass param="(fall_dly<=25n) ? 1:0"
.measure pass param="(rise_dly<=25n) ? ((fall_dly<=25n) ? 1:0) : 0"
****
***** measure for only vwf *****
****
*solve outfile=spice.log
*extract init infile="spice.log"
*extract name="rise_dly" max(da.value."2""rise_dly")
*extract name="fall_dly" max(da.value."2""fall_dly")
*extract name="rise_pass" max(da.value."2""rise_pass")
*extract name="fall_pass" max(da.value."2""fall_pass")
*extract name="pass" max(da.value."2""pass")
Line 29 Col: 33 INS Unix RW SEdit 3.17.9.R © Silvaco 2014

Figure 5-57 Measure Statements

The following measure calculations are performed to monitor the rise/fall delay times for an output signal "OUT" when two input signals "INP" and "INM" are crossed. They are specified within 25n seconds for convenience.

- rise_dly: Delay time when output signal rise.
- fall_dly: Delay time when output signal fall.
- rise_pass: If rise_dly is within 25ns, then it's "1". Otherwise, it is "0".
- fall_pass: If fall_dly is within 25ns, then it's "1". Otherwise, it is "0".
- pass: If rise_pass, fall_pass are both within 25ns, then it's "1". Otherwise, it is, "0".

A section with comment delimiters from line number 24 onwards is used by VWF for displaying a list of measurement results.

A simulation with center condition is run in advance using SmartSpice.

A simulation result can be displayed as a transition of output "OUT" when an input sine wave "INP" crosses an input dc voltage "INM". (Figure 5-57).

5.14 Running SPICE Simulations for 27 Conditions and Review the Results Using VWF

A total of three parameters, "VDD", "tempval", and "capval" are split each with three different values, which creates 27 branches. Quite often, circuit designers use the ".alter" statement to split simulations. But sometimes, it can be tedious to setup the combinations.

VWF helps in setting up split conditions, in monitoring simulation status, and in reviewing all simulation results.

In this example, use the VWF in filemode. Launch VWF by entering the following command in a terminal window:

```
vwf -filemode
```

After creating a new experiment, import the SmartSpice simulation input deck (i.e., comparator_sim.in) that was generated by Gateway. Then, make the following changes:

1. Remove the section with comments from the header and insert "go smartspice" as shown in Figure 5-58.
2. Remove comment delimiters at the bottom of the file, as shown in Figure 5-59, so that VWF will execute the extract statements. These statements will enable VWF to display a list of simulation results.

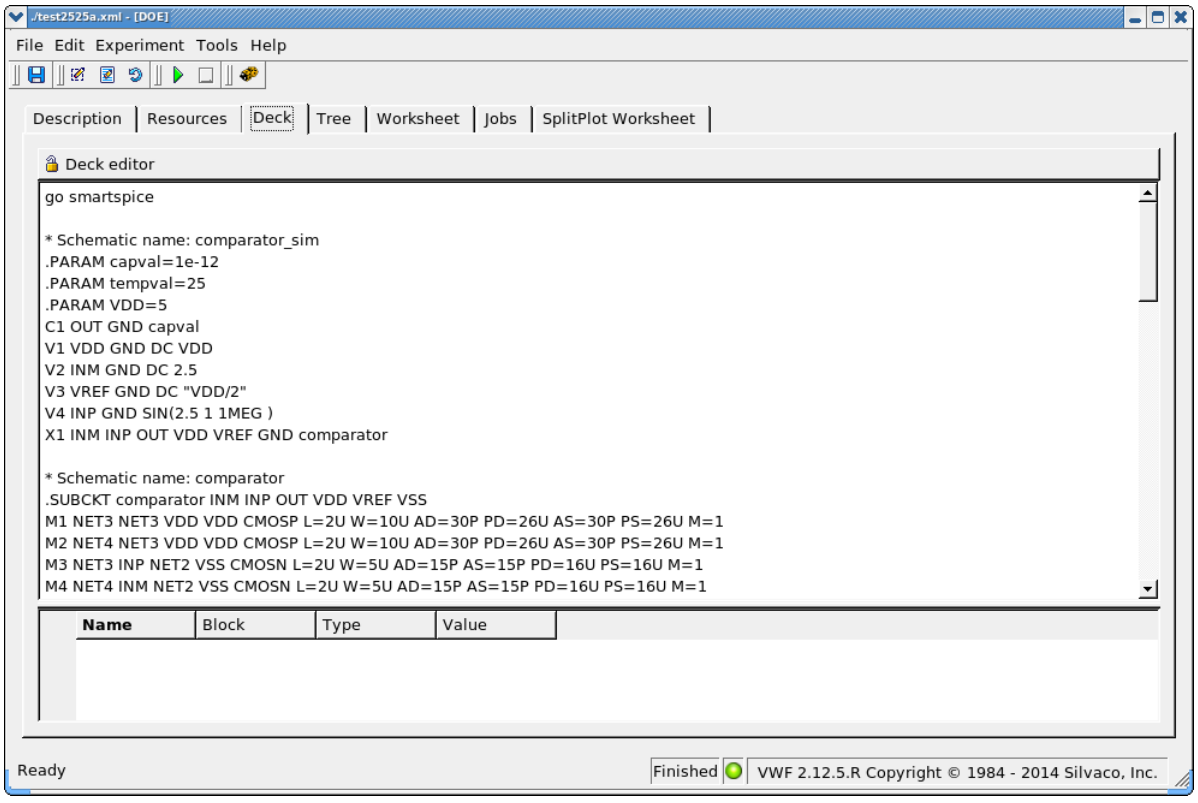

./test2525a.xml - [DOE]
File Edit Experiment Tools Help
Description Resources Deck Tree Worksheet Jobs SplitPlot Worksheet
Deck editor
go smartspice
* Schematic name: comparator_sim
.PARAM capval=1e-12
.PARAM tempval=25
.PARAM VDD=5
C1 OUT GND capval
V1 VDD GND DC VDD
V2 INM GND DC 2.5
V3 VREF GND DC "VDD/2"
V4 INP GND SIN(2.5 1 1MEG)
X1 INM INP OUT VDD VREF GND comparator
* Schematic name: comparator
.SUBCKT comparator INM INP OUT VDD VREF VSS
M1 NET3 NET3 VDD VDD CMOSP L=2U W=10U AD=30P PD=26U AS=30P PS=26U M=1
M2 NET4 NET3 VDD VDD CMOSP L=2U W=10U AD=30P PD=26U AS=30P PS=26U M=1
M3 NET3 INP NET2 VSS CMOSN L=2U W=5U AD=15P AS=15P PD=16U PS=16U M=1
M4 NET4 INM NET2 VSS CMOSN L=2U W=5U AD=15P AS=15P PD=16U PS=16U M=1
Name Block Type Value
Ready
Finished
VWF 2.12.5.R Copyright © 1984 - 2014 Silvaco, Inc.

Figure 5-58 SmartSpice Deck loaded in VWF

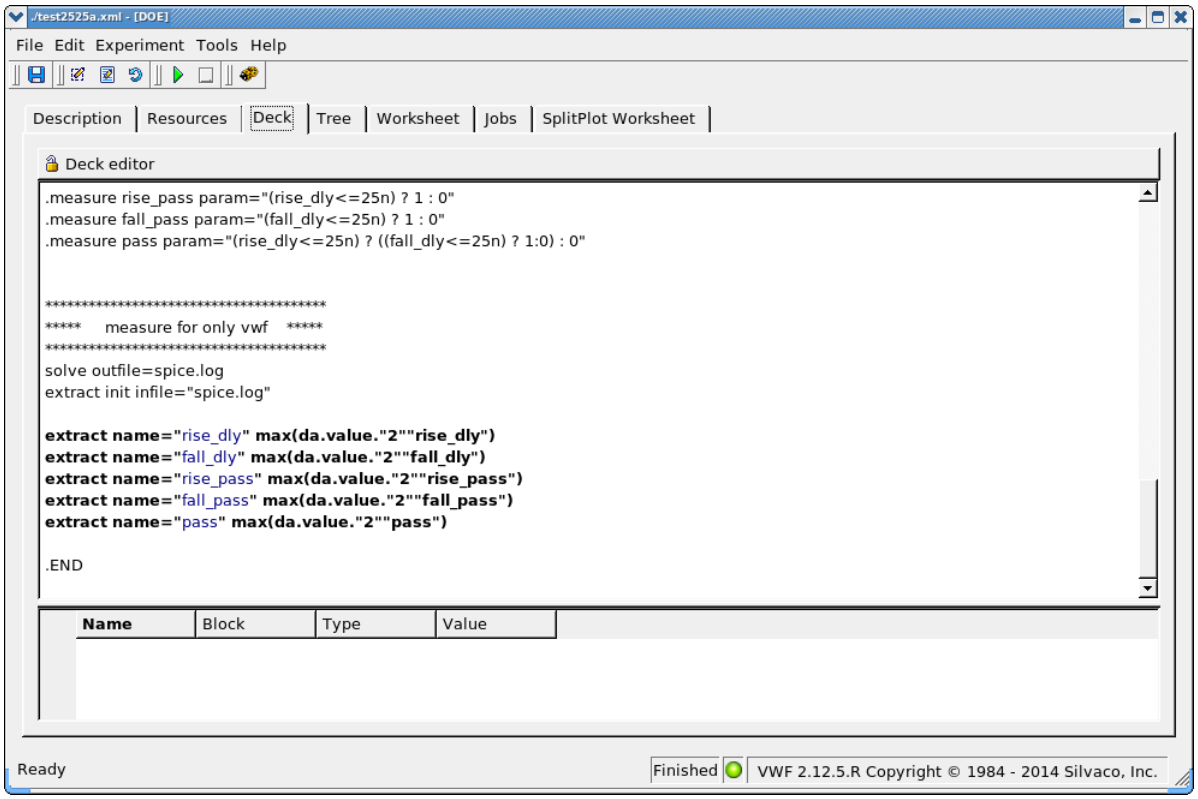


Figure 5-59 Extracting SmartSpice variables in VWF

After loading the edited input deck, define three split parameters, "capval", "tempval", and "VDD" in the VWF deck editor tab. See Figure 5-61.

Split parameters can easily be added when using .PARAM statements in your simulation deck. Simply place the cursor anywhere in the .PARAM statement line and right-click. The VWF interface will search the line for recognizable parameters and list the available parameters in a pop-up form. Then, select the parameter using this form.

For parameters not recognized by the interface, use the following method to enter splits:

1. Highlight a parameter by either double-clicking it or dragging the cursor over the word while holding the left mouse button down.
2. Right-click and select the command "Make selection split".

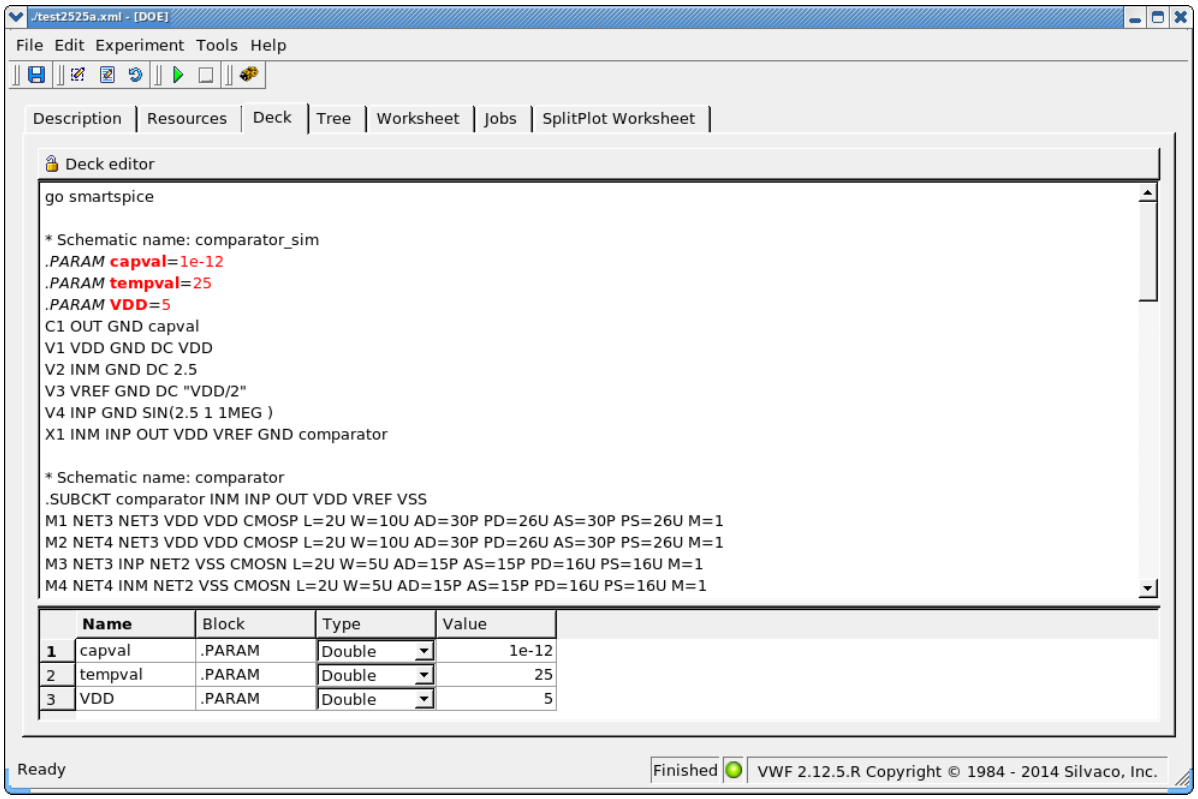

./test2525a.xml - [DOE]
File Edit Experiment Tools Help
Description Resources Deck Tree Worksheet Jobs SplitPlot Worksheet
Deck editor
go smartspice
* Schematic name: comparator_sim
.PARAM capval=1e-12
.PARAM tempval=25
.PARAM VDD=5
C1 OUT GND capval
V1 VDD GND DC VDD
V2 INM GND DC 2.5
V3 VREF GND DC "VDD/2"
V4 INP GND SIN(2.5 1 1MEG)
X1 INM INP OUT VDD VREF GND comparator
* Schematic name: comparator
.SUBCKT comparator INM INP OUT VDD VREF VSS
M1 NET3 NET3 VDD VDD CMOSP L=2U W=10U AD=30P PD=26U AS=30P PS=26U M=1
M2 NET4 NET3 VDD VDD CMOSP L=2U W=10U AD=30P PD=26U AS=30P PS=26U M=1
M3 NET3 INP NET2 VSS CMOSN L=2U W=5U AD=15P AS=15P PD=16U PS=16U M=1
M4 NET4 INM NET2 VSS CMOSN L=2U W=5U AD=15P AS=15P PD=16U PS=16U M=1
Name Block Type Value
1 capval .PARAM Double 1e-12
2 tempval .PARAM Double 25
3 VDD .PARAM Double 5
Ready
Finished
VWF 2.12.5.R Copyright © 1984 - 2014 Silvaco, Inc.

Figure 5-60 Defining Split Parameters in VWF

After selecting the split parameters, you can set all 27 conditions in only three steps in the VWF tree tab.

1. Define splits for the "VDD" parameter as 5V±10%. To do so, change into either the tree or the worksheet tab. Then, open the dialog to add branches by right-clicking on the VDD parameter and selecting **Add multiple branches**. The dialog is shown in Figure 5-61. There are several ways to enter splits. In this example, a percentage is defined (10%). After pressing Enter, the branches are added and the tree will look as shown in Figure 5-62.
2. Repeat step 1 for the "tempval" parameter. This time a list of values (-40,25,120) is used. (Figure 5-63). Note the changed tree view after you press Enter (Figure 5-64).
3. Repeat step 1 once more to define "capval" as shown in Figures 5-65 and 5-66.

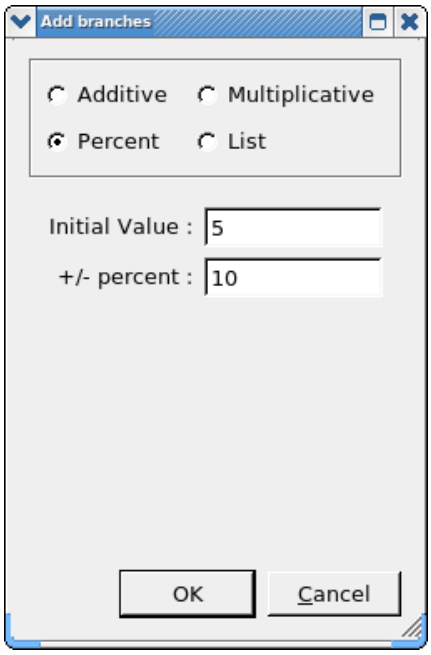


Figure 5-61 Adding splits for the VDD parameter

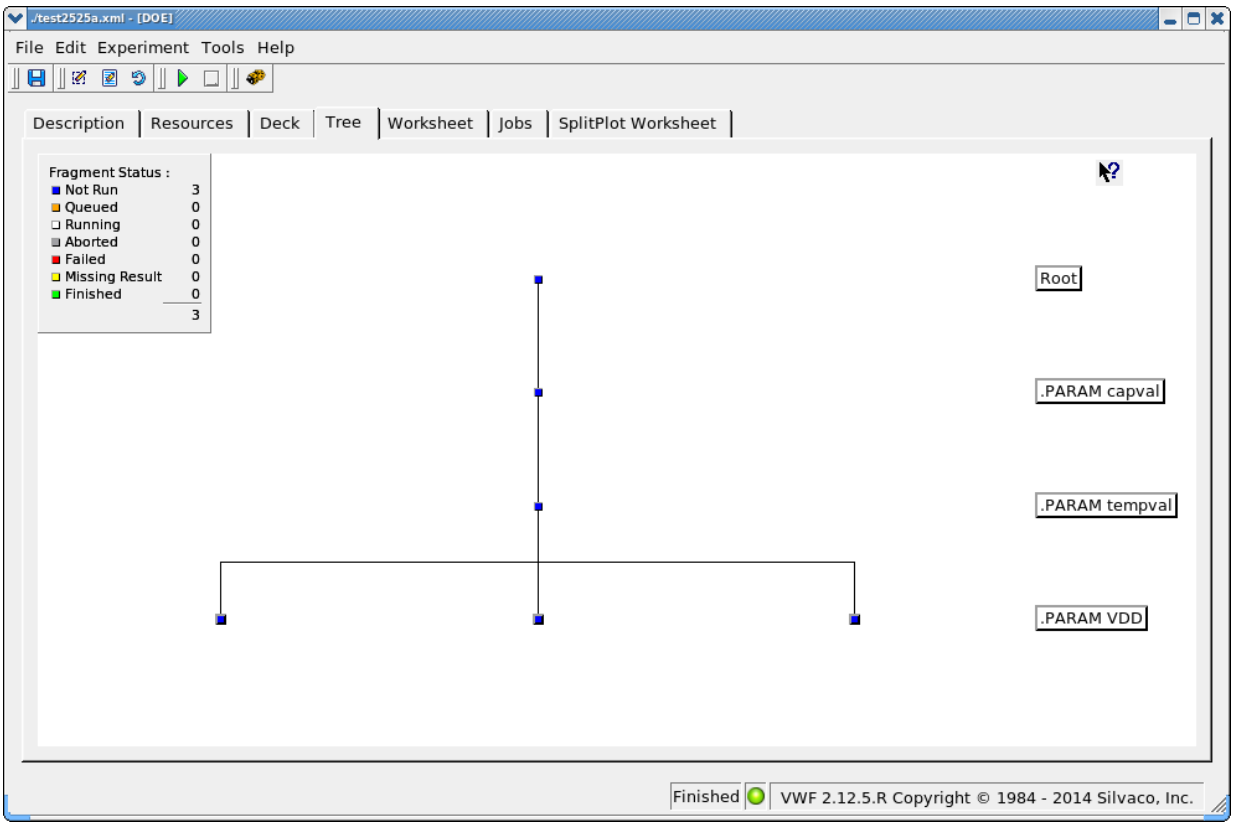


Figure 5-62 Split tree after VDD split definition

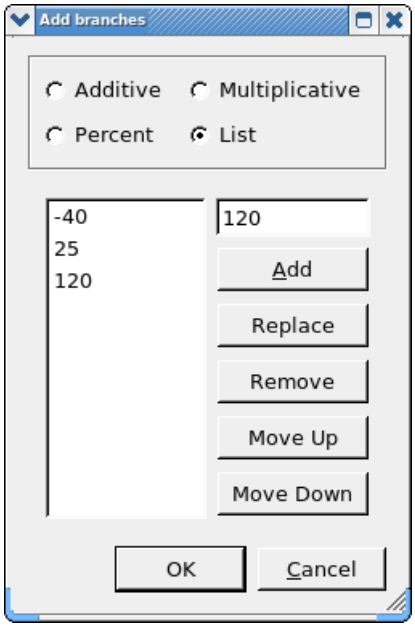


Figure 5-63 Adding splits for the tempval parameter

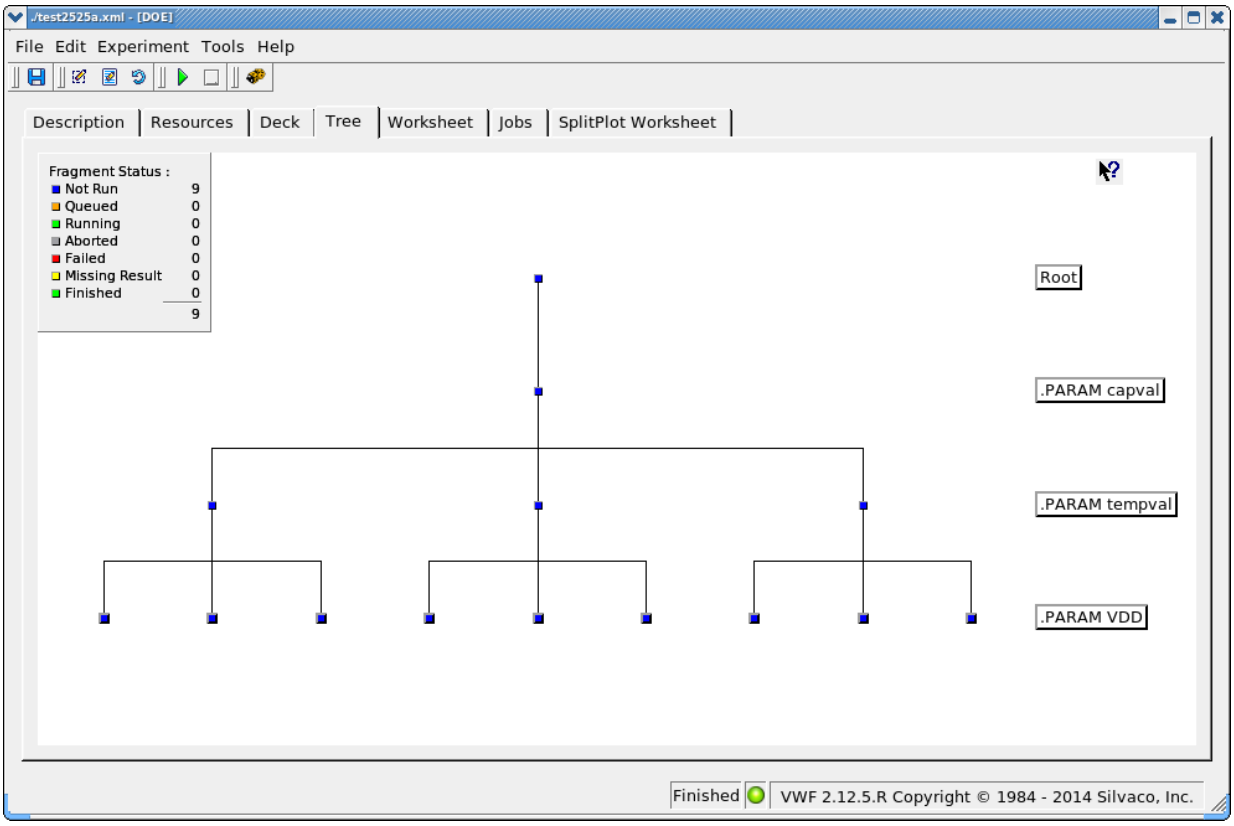


Figure 5-64 Split tree after the tempval split definition

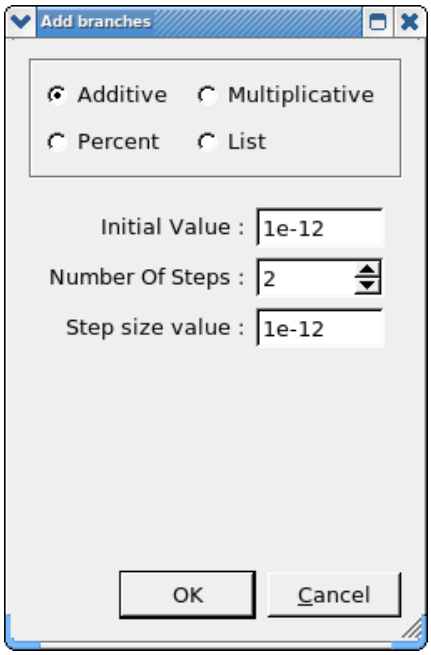


Figure 5-65 Adding splits for the capval parameter

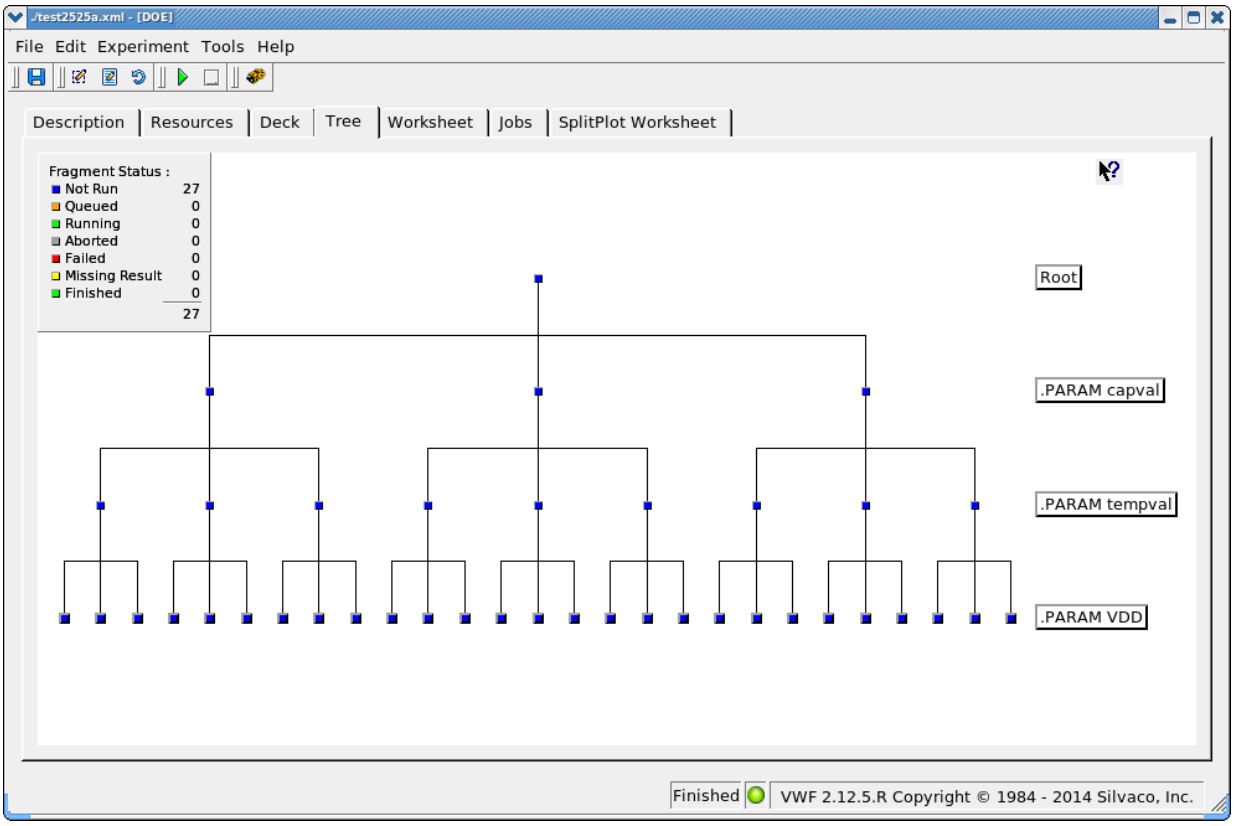


Figure 5-66 Split tree after the capval definition

Now you are ready to run the simulations. You can decide to queue all branches or just a subset thereof. Depending on your setup, simulations are either run locally on your workstation or on a queuing system, like Oracle Grid Engine or LSF. The quickest way of running all branches is to hit the run button.

While the experiment is executing, you can view the progress in the tree and worksheet tabs. Running simulations will be flashing green. A successfully finished simulation will be indicated as a solid green node. Finally, errors are indicated by red nodes (Figure 5-67).

The content of the worksheet is updated as simulation results become available (Figure 5-68).

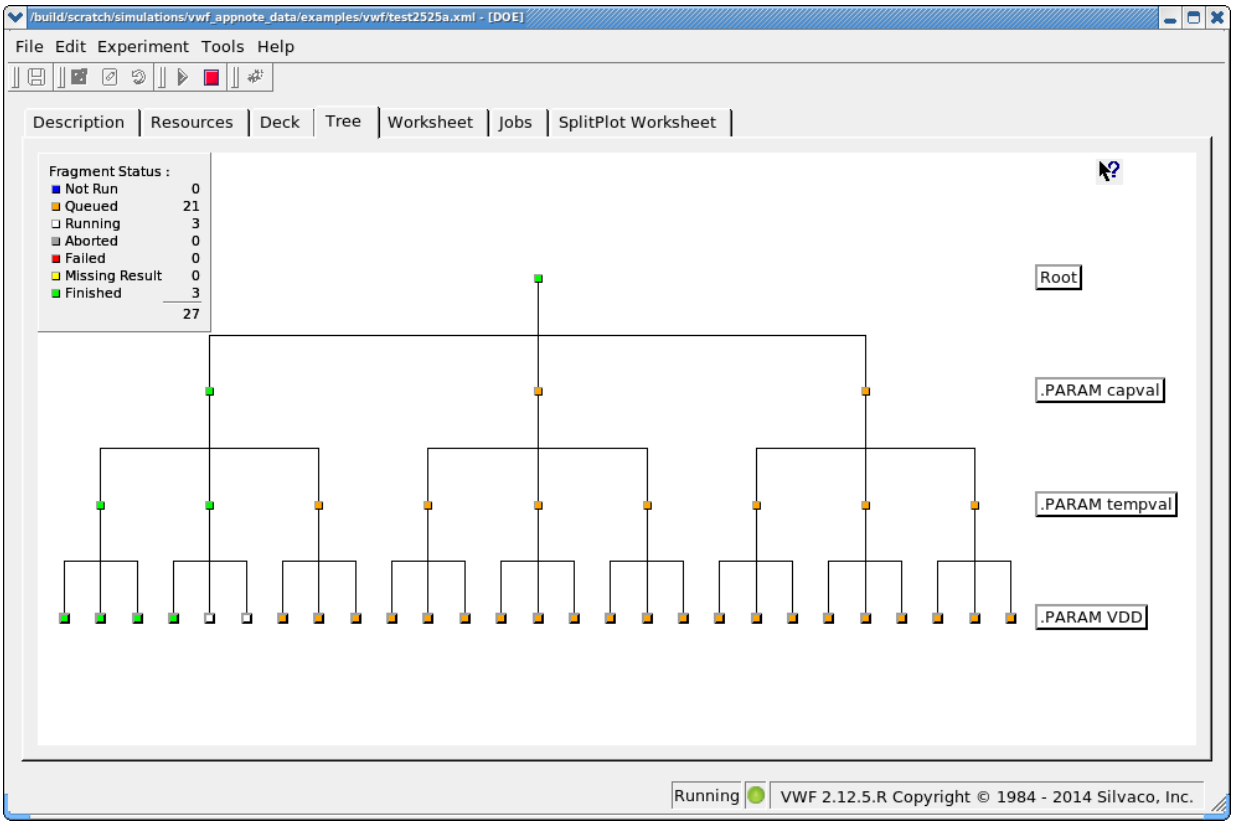
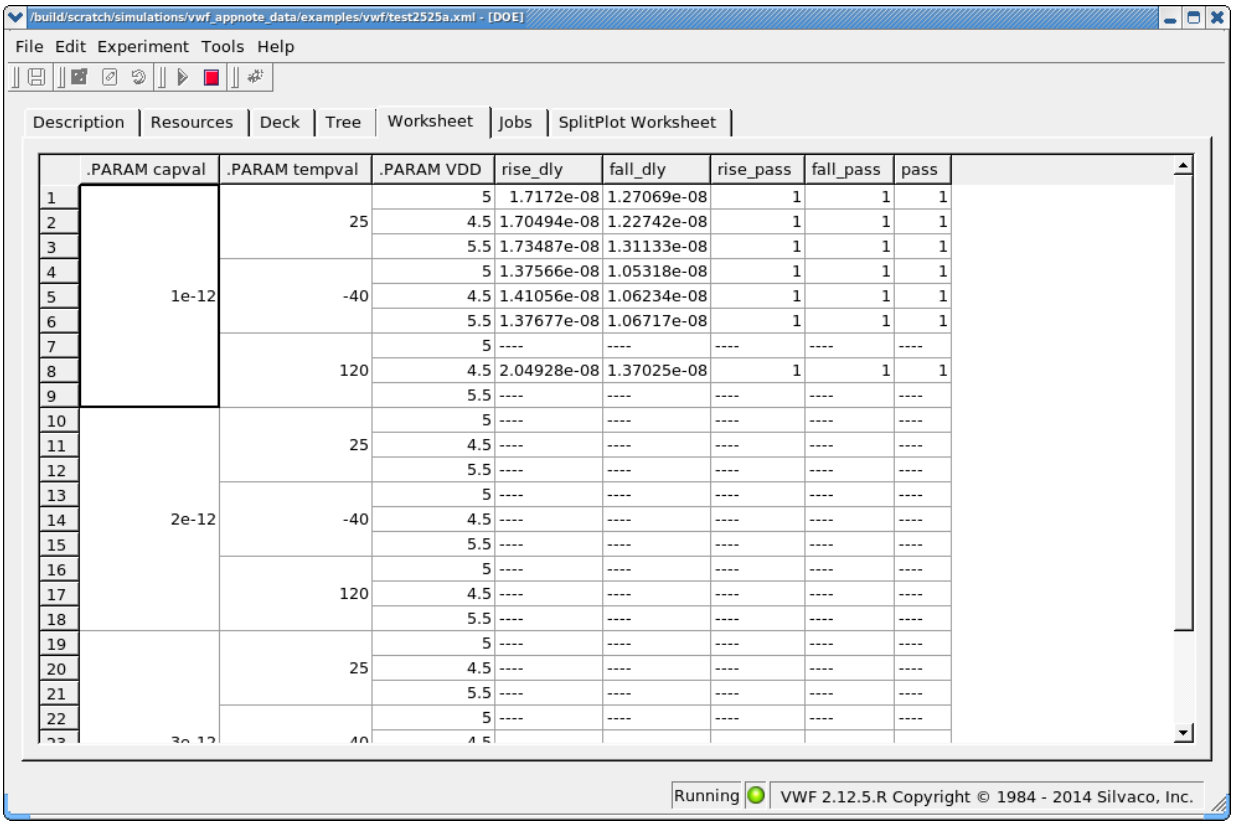


Figure 5-67 Progress of running experiment


/build/scratch/simulations/vwf_appnote_data/examples/vwf/test2525a.xml - [DOE]
File Edit Experiment Tools Help
Description Resources Deck Tree Worksheet Jobs SplitPlot Worksheet
Running
VWF 2.12.5.R Copyright © 1984 - 2014 Silvaco, Inc.

	.PARAM capval	.PARAM tempval	.PARAM VDD	rise_dly	fall_dly	rise_pass	fall_pass	pass
1	1e-12	25	5	1.7172e-08	1.27069e-08	1	1	1
2			4.5	1.70494e-08	1.22742e-08	1	1	1
3			5.5	1.73487e-08	1.31133e-08	1	1	1
4		-40	5	1.37566e-08	1.05318e-08	1	1	1
5			4.5	1.41056e-08	1.06234e-08	1	1	1
6			5.5	1.37677e-08	1.06717e-08	1	1	1
7		120	5	----	----	----	----	----
8			4.5	2.04928e-08	1.37025e-08	1	1	1
9			5.5	----	----	----	----	----
10	2e-12	25	5	----	----	----	----	----
11			4.5	----	----	----	----	----
12			5.5	----	----	----	----	----
13		-40	5	----	----	----	----	----
14			4.5	----	----	----	----	----
15			5.5	----	----	----	----	----
16		120	5	----	----	----	----	----
17			4.5	----	----	----	----	----
18			5.5	----	----	----	----	----
19	3e-12	25	5	----	----	----	----	----
20			4.5	----	----	----	----	----
21			5.5	----	----	----	----	----
22		40	5	----	----	----	----	----

Figure 5-68 Live update of extracted parameters in the worksheet

Note: A more elaborate version of this example is shipped with the VWF software.

Chapter 6
Optimization in VWF

VWF comes with a set of powerful optimization algorithms. If you are already familiar with optimization in UTMOST-IV, then you will find the supported optimization algorithms and their parameters straight-forward and simple to use.

The idea of optimization in VWF is to directly optimize a target variable by tuning split parameters automatically rather than using a predefined split tree. The optimization algorithm will choose a set of values for your split variables so that a chosen target (function) will be minimized. One notable difference between optimization and DOE is that in an optimization experiment the number of jobs (simulations) that are executed cannot generally be told in advance. Whereas in a DOE, the exact number of jobs is already known in advance and solely depends on the split tree. It is therefore evident that the concept of a split tree does not make sense for optimization. Instead, a table of simulation results is kept and filled with data as simulation jobs are finished.

The optimization capability in VWF – while often applied in that manner – is not limited to sole curve fitting problems. Instead, it can be applied in a more generic way to solve various optimization tasks ranging from model calibration over inverse modeling to process optimization and others. Optimization is supported to be used together with any of the Silvaco simulators that are available from within VWF.

6.1 Supported Optimization Algorithms

The following Silvaco standard optimization algorithms are supported from VWF:

- **Levenberg-Marquardt (LM)** – Gradient-based local optimization strategy. This is a standard nonlinear least-squares problem solver and works very well in practice if a reasonably good initial vector of parameter values is available. This is used most efficiently for curve fitting problems. Due to the nature of this algorithm, the optimizer can be caught in a local minima.
- **Hooke-Jeeves Method (HJ)** – Local optimization strategy. While the LM optimizer described above is also a local optimizer, there are some important differences between the two. LM calculates numerical derivatives, but HJ belongs to the class of direct search algorithms and these do not use derivatives. In this respect, HJ is similar to the global optimizers.
- **Simulated Annealing (SA)** – Global optimization strategy. The SA method mimics the formation of an actual physical solid from a liquid as the liquid cools. At high temperature, the liquid is highly disordered, its components are free to move and its energy is high. As the temperature is lowered, so the energy of the system falls. If the cooling process is slow enough, an ordered solid (such as a crystal) of the lowest possible energy will form.
- **Parallel Tempering (PT)** – Global optimization strategy. PT is related to SA, but instead of mimicking the gradual cooling process of a single physical system, it consists of an ensemble of systems at different and fixed temperatures. The elements of this ensemble are called replicas. Each replica carries its own copy of the optimization parameters. The values in different replicas will diverge as the optimization proceeds.
- **Genetic Algorithm (GA)** – Global optimization strategy. GA is an evolutionary algorithm, that is, it uses techniques inspired by evolutionary biology. GA works with a population of candidate solutions to the optimization problem. At each step, it generates a new population from the old. The idea is that the cost function plays the role of the evolutionary pressures found in nature and causes the evolution of a population that gives better values of the cost function.
- **Differential Evolution (DE)** – Global optimization strategy. DE is an evolutionary algorithm, that is, it uses techniques inspired by evolutionary biology. The main difference between the GA and DE optimizers is in the way new generations are created. DE uses differences between population members for creating trial solutions, while GA operates directly on the population members. DE operates by constructing a linear combination of two or more randomly selected members of the existing population.

6.2 Optimization Loop

The optimization process carried out in VWF can be seen as a loop, where the optimizer acts as an independent component, which requests targets for parameter values to be computed by VWF. VWF simulates each parameter combination and collects the targets for all carried out simulations. The targets are then fed back to the optimizer, which in turn requests targets for new parameter values. The optimizer chooses the parameter values so that the target decreases. When the target is within a certain tolerance, the optimizer finishes and the experiment terminates.

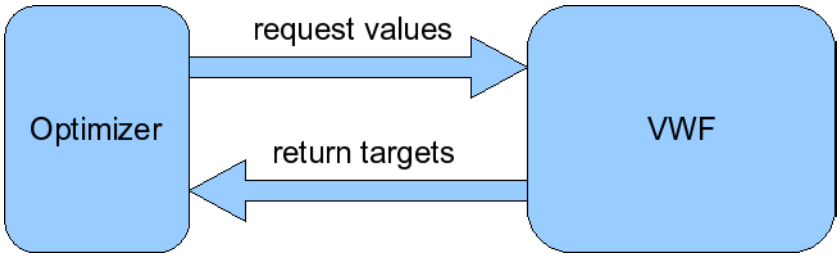


Figure 6-1 Optimization Loop

Figure 6-1 illustrates that loop. The way how parameter values are chosen strongly depends on the selected optimization algorithm. A genetic algorithm uses a different strategy as does simulated annealing or a gradient-based optimizer.

A VWF built-in algorithm takes care of computing the optimizer target values (return targets in Figure 6-1) out of the simulator responses and the user entered target values. The algorithm computes a component-wise absolute error vector. Depending on whether the optimizer requires a vector or scalar target, the error vector is either directly passed on to the optimizer or a root mean square is computed (e.g., for a genetic optimizer). If this default algorithm is not suitable for the problem at hand, then you can optionally chose to run a user-definable JavaScript script to compute the optimizer target.

When it comes to grid computing, it is important to note that an optimization process is not strictly serial in the sense that only one evaluation is requested at a time. Instead, most optimizers are capable of requesting several evaluations in parallel. This is true for a genetic optimizer, who will request the evaluation of a whole population, but also for the gradient-based Levenberg-Marquardt optimizer. In order to best utilize a given grid environment, it can make sense to tune certain optimizer settings. For example, it's a good idea to make the population size of a genetic optimizer not much smaller as there are CPUs on the grid.

Note, also, that an optimizer, which is incapable of performing parallel evaluations is not of much use on a computational grid. This is because the time to compute the target (simulation time) is rather large and will normally dominate the whole optimization process. Speed-up of the optimization process will only be achieved if several CPUs can be utilized at the same time.

6.3 Defining an Optimization Experiment

Here are the tasks that you need to perform to run an optimization experiment:

1. A baseline deck needs to be imported into VWF (same step as for DOE)
2. An optimization experiment needs to be created. The type of the experiment will be different than DOE.
3. Split variables need to be identified (same step as for DOE).
4. [optional] A tree for some of the split variables can be defined. VWF runs all simulations defined by that tree for every optimizer iteration. You have to define a template tree if you want to use several sets of measurements as targets in your optimization problem.
5. An optimization algorithm needs to be selected.
6. An optimization target must be defined. Depending on the selected optimization algorithm this can either be a scalar or a vector target.
7. [optional] Optimizer settings can be defined. For example, for the genetic algorithm the population size, crossover probabilities and mutation probabilities can be set. If not changed, default values will be used. Among other things the truncation criterion(s) can be defined.
8. Optimization is started by using the VWF **Run** button ( ).
9. Progress of optimization can be monitored by looking at the progress of the target as the optimization proceeds.
10. The optimization is finished when the truncation criterion is reached for the target. This means the computed target is now within the defined accuracy (or another criterion like the maximum number of simulations was hit).
11. You can stop the optimization anytime using the **Stop** button ( ).

When a new experiment is created, it must be decided whether this is an optimization or a DOE type experiment. This type cannot be changed later. Figure 6-2 depicts the dialog, which opens when a new experiment is to be created. You can decide to either create a DOE type experiment or an optimization experiment using one of the supported optimization algorithms.

The basic type of the experiment (DOE or optimization) cannot be changed afterwords, but the optimization algorithm can be changed. If you want to run an experiment with different optimization algorithms, you can first fully define the experiment using one optimizer, then save it, use copy/paste, and change the optimization algorithm in the copied experiment.

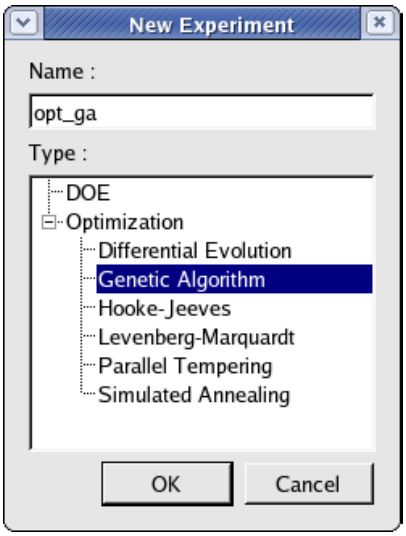


Figure 6-2 Definition of New Optimization Experiment

Figure 6-3 shows the main window after an optimization experiment was created. You can see the type of this experiment was selected to be **Genetic Algorithm**. Also, if you compare this window to the DOE type (Figure 3-27) experiment window, you can see that some of the tabs have changed. The tabs **Tree** and **SplitPlot Worksheet** are not available for optimization experiments, whereas tabs **Parameters**, **Setup**, **Results**, and **Graphics** are not available for DOE experiments.

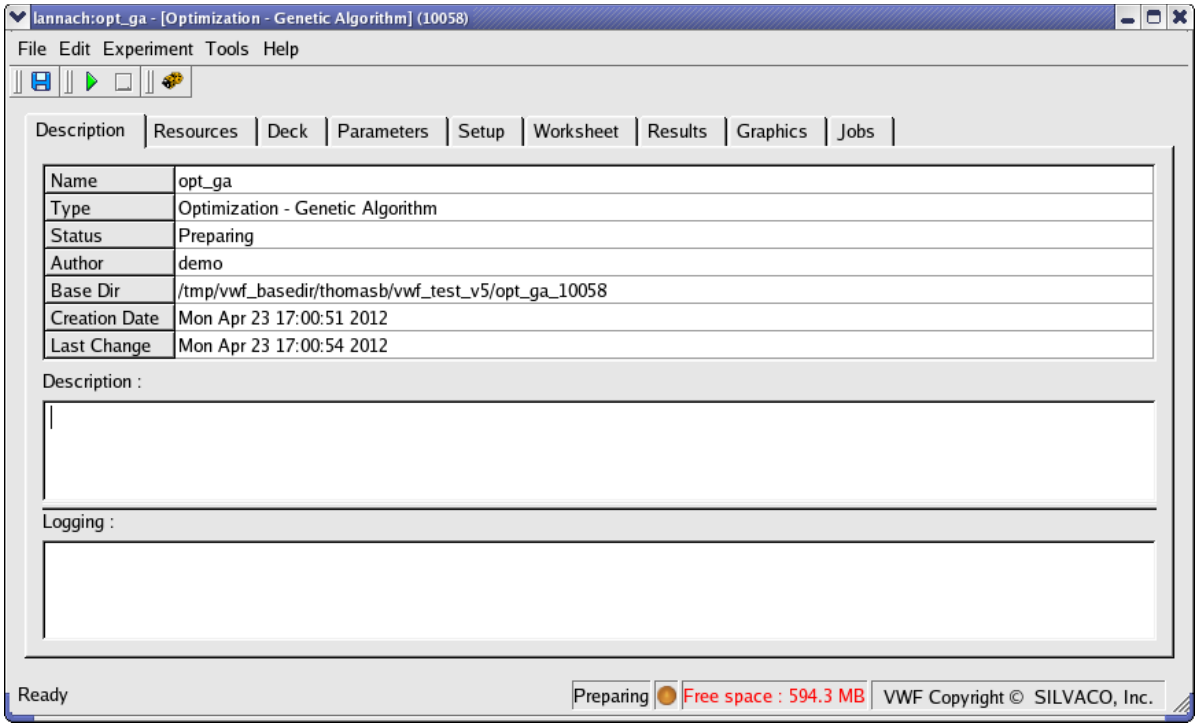

lannach:opt_ga - [Optimization - Genetic Algorithm] (10058)
File Edit Experiment Tools Help
Description Resources Deck Parameters Setup Worksheet Results Graphics Jobs
Name opt_ga
Type Optimization - Genetic Algorithm
Status Preparing
Author demo
Base Dir /tmp/vwf_basedir/thomasb/vwf_test_v5/opt_ga_10058
Creation Date Mon Apr 23 17:00:51 2012
Last Change Mon Apr 23 17:00:54 2012
Description :
Logging :
Ready
Preparing
Free space : 594.3 MB
VWF Copyright © SILVACO, Inc.

Figure 6-3 Optimization Experiment Window

6.4 Defining Optimization Parameters

The first step after creating the optimization experiment is to define the parameters that will be tuned by the optimizer. The definition is done similar to a DOE experiment by selecting the parameter in the deck editor. Additionally, lower and upper bounds for that parameter must be given. This avoids the optimizer choosing nonsensical values for a parameter. This is done in the exact same manner as for the DOE type experiment. Figure 6-4 depicts the context menu, which is shown when you right-click over a deck line.

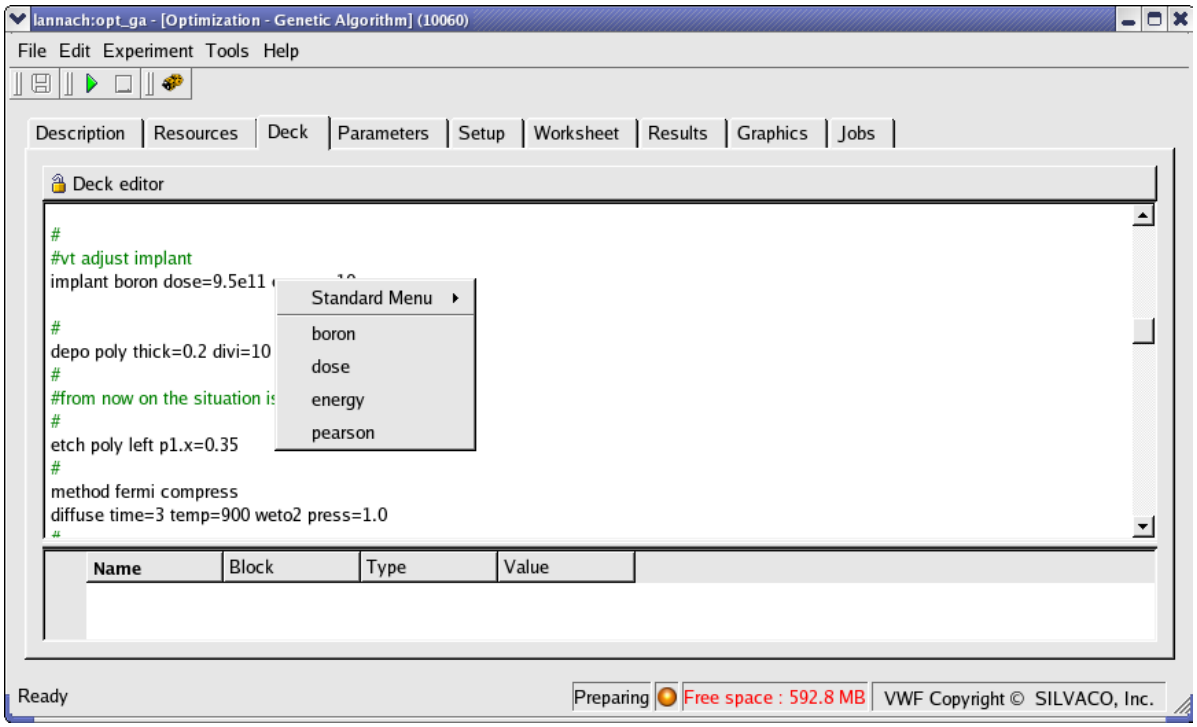


Figure 6-4 Defining Split Parameters

6.5 Defining Parameter Boundaries

Figure 6-5 shows the parameters tab. You can see that you can change the minimum and maximum values, you can decide this parameter to be a DOE parameter, and you can select the scaling type for each parameter. Selecting a parameter to be of type DOE will exclude it from being used by the optimizer. Instead, you can define a tree of parameter combinations for all DOE type parameters. All combinations are then run for each optimizer iteration. This is useful if you have several sets of measurements for parameters which you don't want to optimize. For example, you may have measurements for several mask widths but the mask width itself is not an optimization parameter. Please refer to Section 6.7 "Optimization Example: Advanced Calibration Task" for an example to demonstrate this functionality.

This version of the software supports linear and logarithmic parameter scaling. Setting a parameter to logarithmic has the effect that the natural logarithm of the value is given to the optimizer rather than the value itself. For the shown example, the boundaries for the parameter dose as exposed to the optimizer will be

```
ln(4.75e11) = 26.89 and ln(1.43e12) = 27.99.
```

Whereas, the boundaries for the parameter energy will be between `5` and `15`.

The values that are used for the actual simulation, however, will always be the unscaled ones. In this example, this would mean that for the parameter dose a value between `4.75e11` and `1.43e12` and for the parameter `energy` a value between `5` and `15` would be used in the simulation.

As with DOE type experiments, the default values chosen for parameter boundaries are `+-50%` of the nominal value.

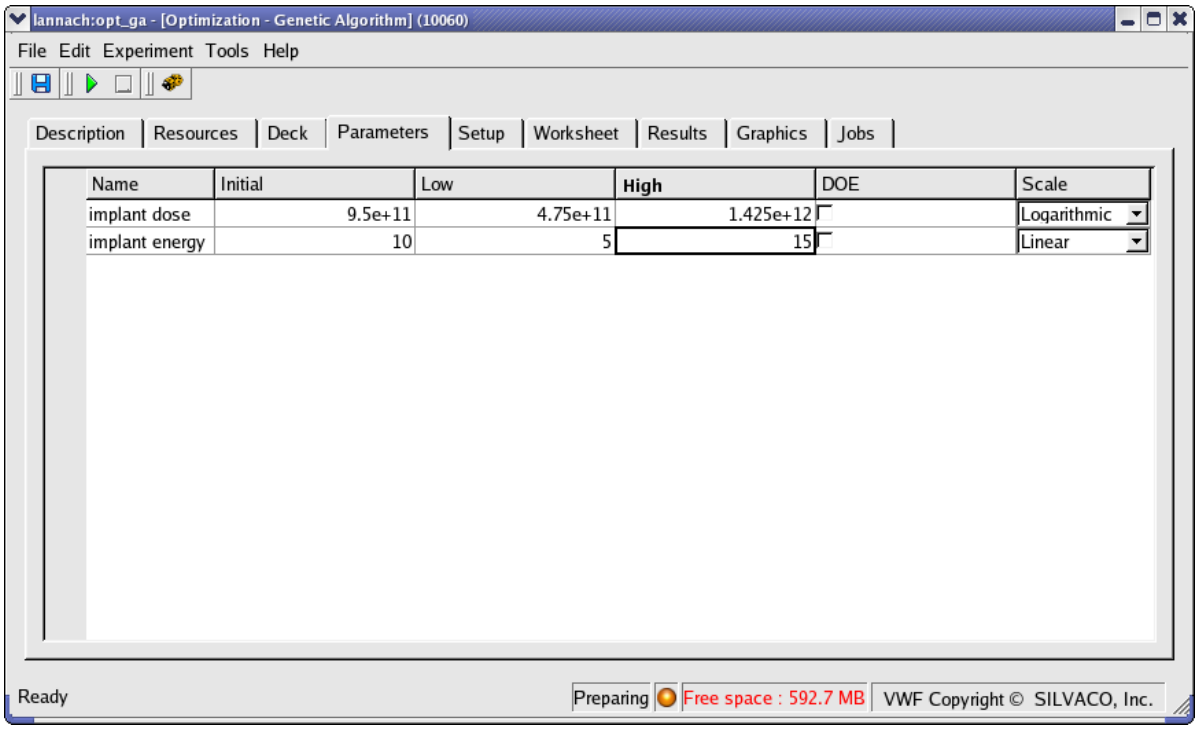

lannach:opt_ga - [Optimization - Genetic Algorithm] (10060)
File Edit Experiment Tools Help
Description Resources Deck Parameters Setup Worksheet Results Graphics Jobs
Name Initial Low High DOE Scale
implant dose 9.5e+11 4.75e+11 1.425e+12 Logarithmic
implant energy 10 5 15 Linear
Ready
Preparing
Free space : 592.7 MB
VWF Copyright © SILVACO, Inc.

Figure 6-5 Defining Parameter Boundaries

6.6 Defining Optimizer Target and Settings

Defining the target of the optimization problem is probably the most crucial part of the optimization experiment. Various approaches depending on the nature of the optimization problem at hand are possible. VWF attempts to make this process as simple as possible while maintaining a high degree of flexibility, so that a wide range of optimization problems can be formulated and solved.

Depending on the chosen optimization algorithm, a target is either a vector of real-valued numbers or a single (scalar) real-valued number. VWF supports both kinds of targets. As an example for scalar targets, process variables, like thicknesses or junction depths, or variables like voltages, currents, capacitances can be mentioned. Examples for vector targets can be I/V curves or (1D) doping profiles or also a set of several scalar targets merged into a vector.

Figure 6-15 shows the setup tab of the experiment window, which is used to select the target. When the baseline is imported, all EXTRACT statements are setup as potential targets. The main pane of the setup tab shows all these targets. Before an optimization can be started, exactly one target must be selected for optimization. In the setup pane, you can also define an optional repeat count for simulations. If a simulation fails, it is repeated until it succeeds or the repeat count is exceeded. A value of 0 for the repeat count means that simulations are not repeated. A failing simulation will stop the optimizer and no further iterations are performed. Before the optimization experiment is restarted, it is advisable to investigate the reason for the failure by looking into the runtime output of the simulation, which has failed.

For a selected target, you can choose to define a value to achieve (for instance a certain voltage). In this case, the optimizer minimizes the difference between the selected target and the entered target value. Or, you can decide not to enter a value and let the optimizer find the minimum of the selected target. This can be useful if your target already is a measure of difference (e.g., least squares error between two curves). A separate target language is available in the DBInternal tool for more advanced target definitions. Please refer to Section 6.6.6 “Target Definition Language” for details.

An alternative way of computing the target is to use a JavaScript script. Figure 6-6 shows the **Worksheet** tab with a target script to compute a vector target.

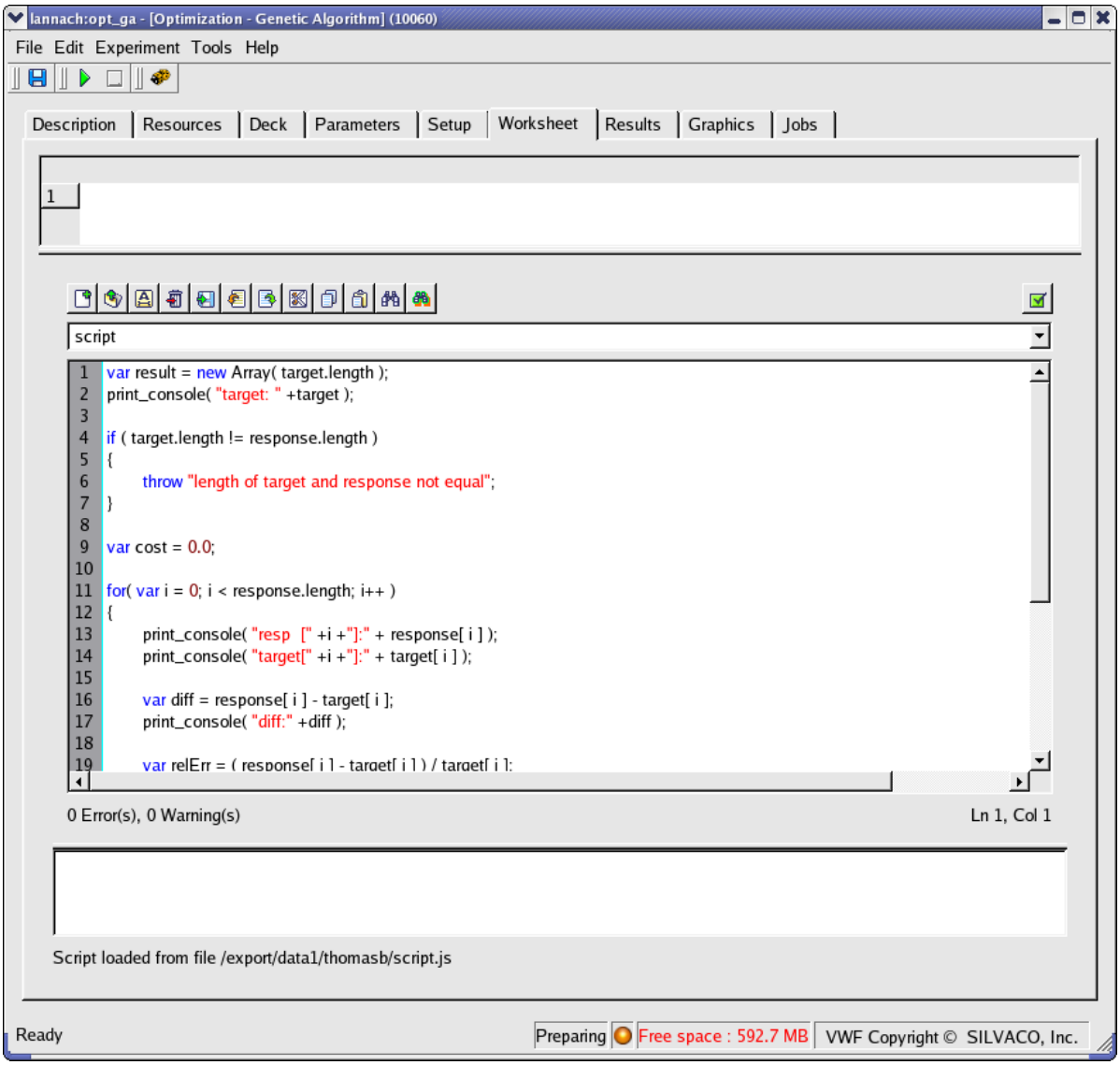

lannach:opt_ga - [Optimization - Genetic Algorithm] (10060)
File Edit Experiment Tools Help
Description Resources Deck Parameters Setup Worksheet Results Graphics Jobs
1
script
1 var result = new Array(target.length);
2 print_console("target: " +target);
3
4 if (target.length != response.length)
5 {
6 throw "length of target and response not equal";
7 }
8
9 var cost = 0.0;
10
11 for(var i = 0; i < response.length; i++)
12 {
13 print_console("resp [" +i +"]:" + response[i]);
14 print_console("target[" +i +"]:" + target[i]);
15
16 var diff = response[i] - target[i];
17 print_console("diff:" +diff);
18
19 var relErr = (response[i] - target[i]) / target[i];
0 Error(s), 0 Warning(s)
Ln 1, Col 1
Script loaded from file /export/data1/thomasb/script.js
Ready
Preparing
Free space : 592.7 MB
VWF Copyright © SILVACO, Inc.

Figure 6-6 Using a Target Script

The Worksheet pane consists of three parts. In the top-most part, target values can be entered for DOE type parameters. The middle part allows to select, edit, and debug a target script. The bottom most part shows debug output from the target script. The functionality and advantage of scripted optimization is best illustrated by an example. Please refer to Section 6.7 “Optimization Example: Advanced Calibration Task” for an example of how a target script can be used to calibrate an ion enhanced chemical etching (IECE) model of the 3D process simulator Victory Process.

6.6.1 Target Script Editor

The script part of Figure 6-6 allows you to edit the script text. Additionally, there are several icons. Starting from the left hand side, the icons have the following meaning.

Define a New Target Script

Figure 6-7 depicts the dialog shown when the left-most icon is clicked. A name for the new script must be entered. After the dialog is closed using the **OK** button, the scroll down menu can be used to select among all available scripts (Figure 6-8).

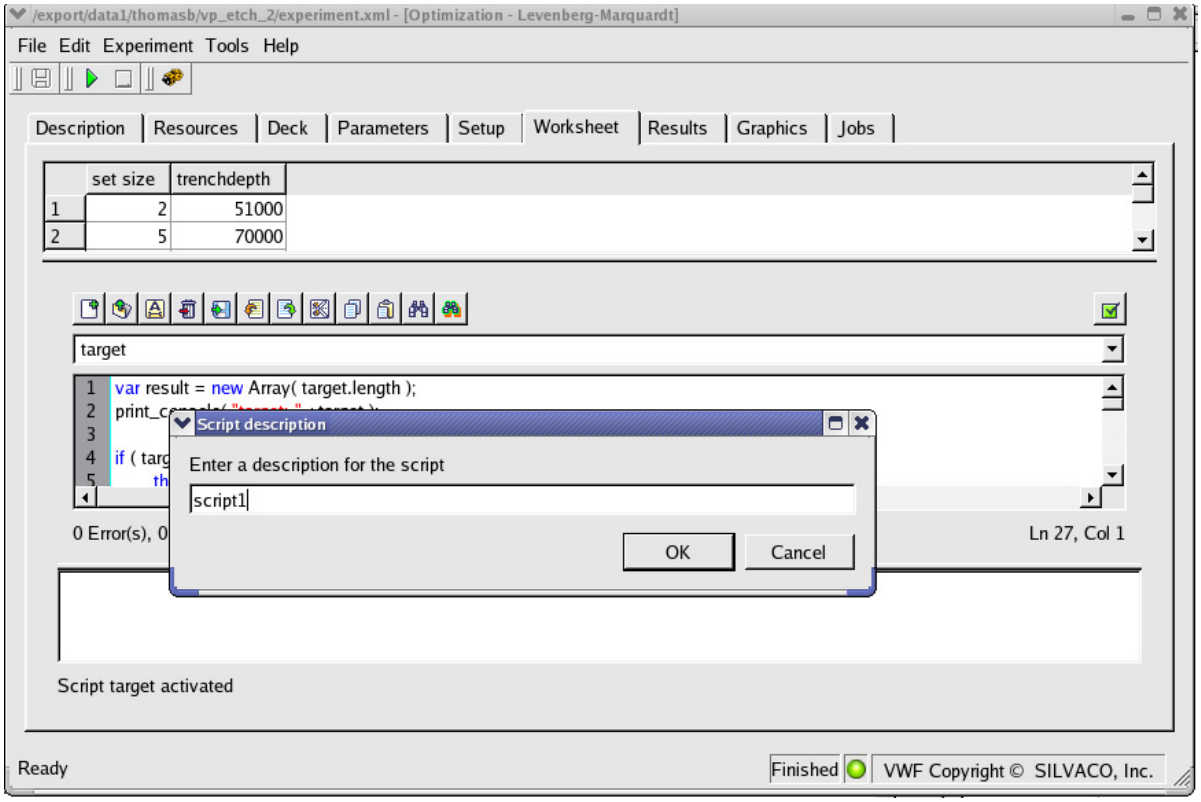


Figure 6-7 Defining a New Target Script

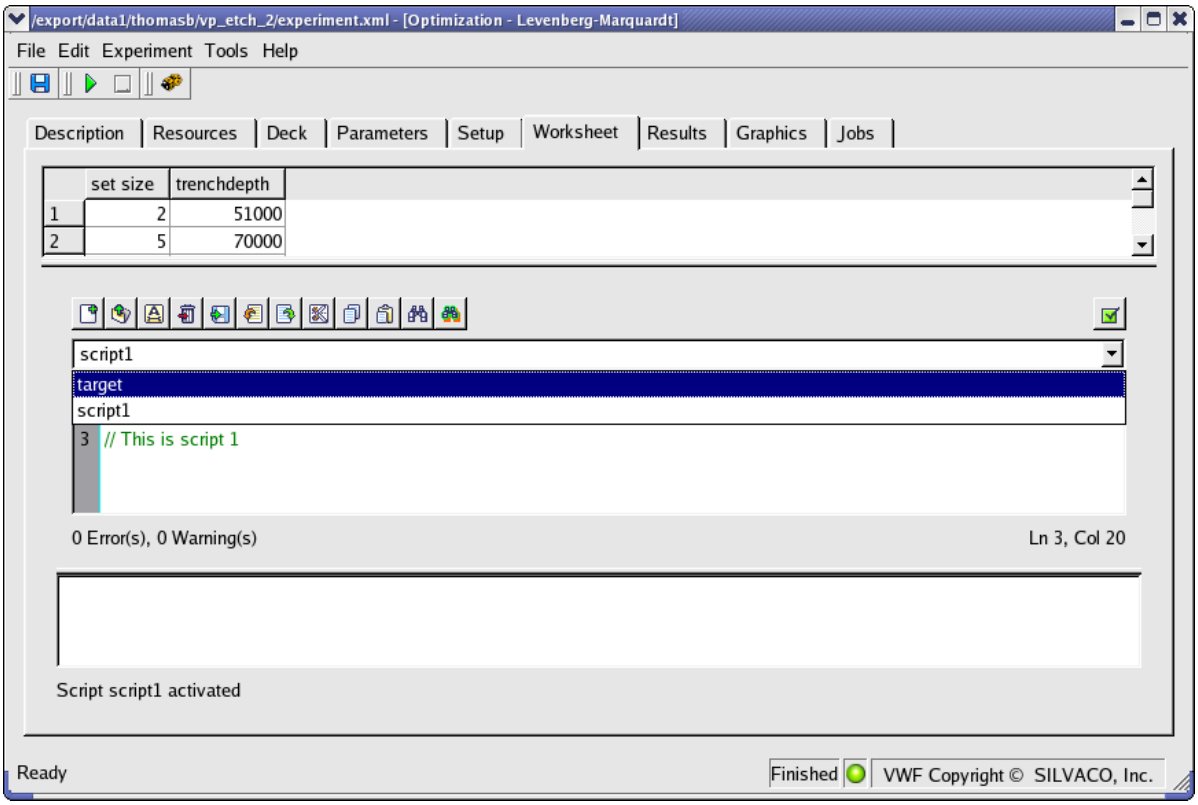


Figure 6-8 Select Among Several Target Scripts

You can store several target scripts with an experiment but only one of them can be active at a time. The active script is the one that is visible in the editor. All operations, like editing, saving, or deleting always impact the active script.

Load a Target Script from Disk

Figure 6-9 shows how a script can be loaded from disk. After activating the **Load** button (second from left), a dialog as shown opens allowing you to select a script.

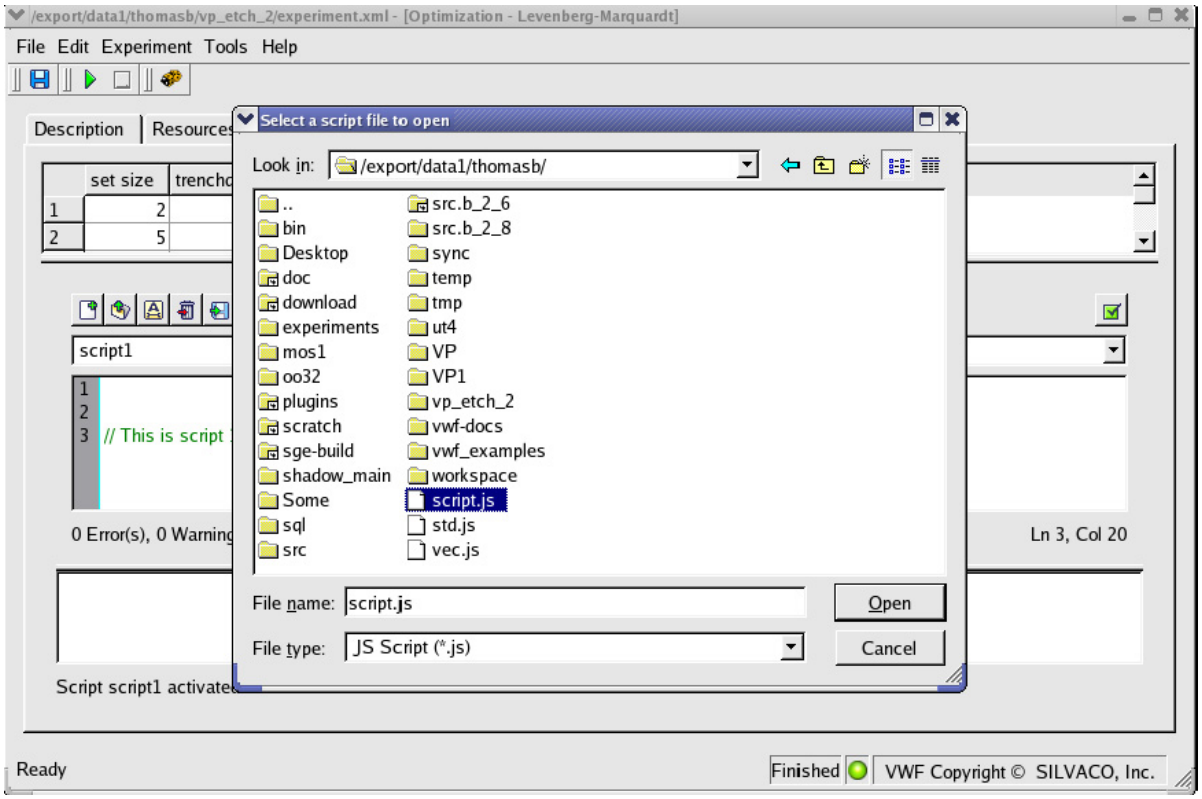


Figure 6-9 Loading a Script from Disk

Change the name of a script (description)

Figure 6-10 shows how the one line description of the script can be changed by using the third button from the left.

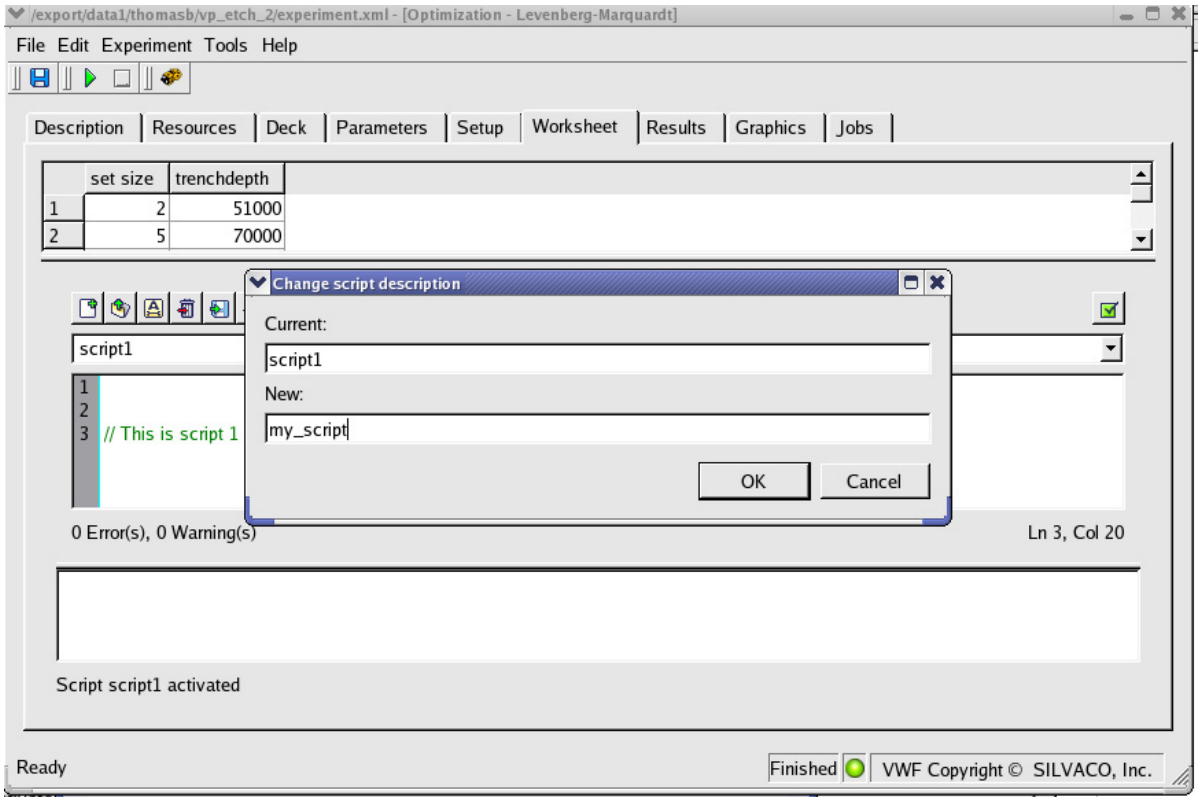


Figure 6-10 Change Description of Script

Deleting a Script

Figure 6-11 shows the dialog, which opens when you click on the trash icon (fourth from left). You can decide to cancel the operation or to select **Ok**, in which case the script is removed.

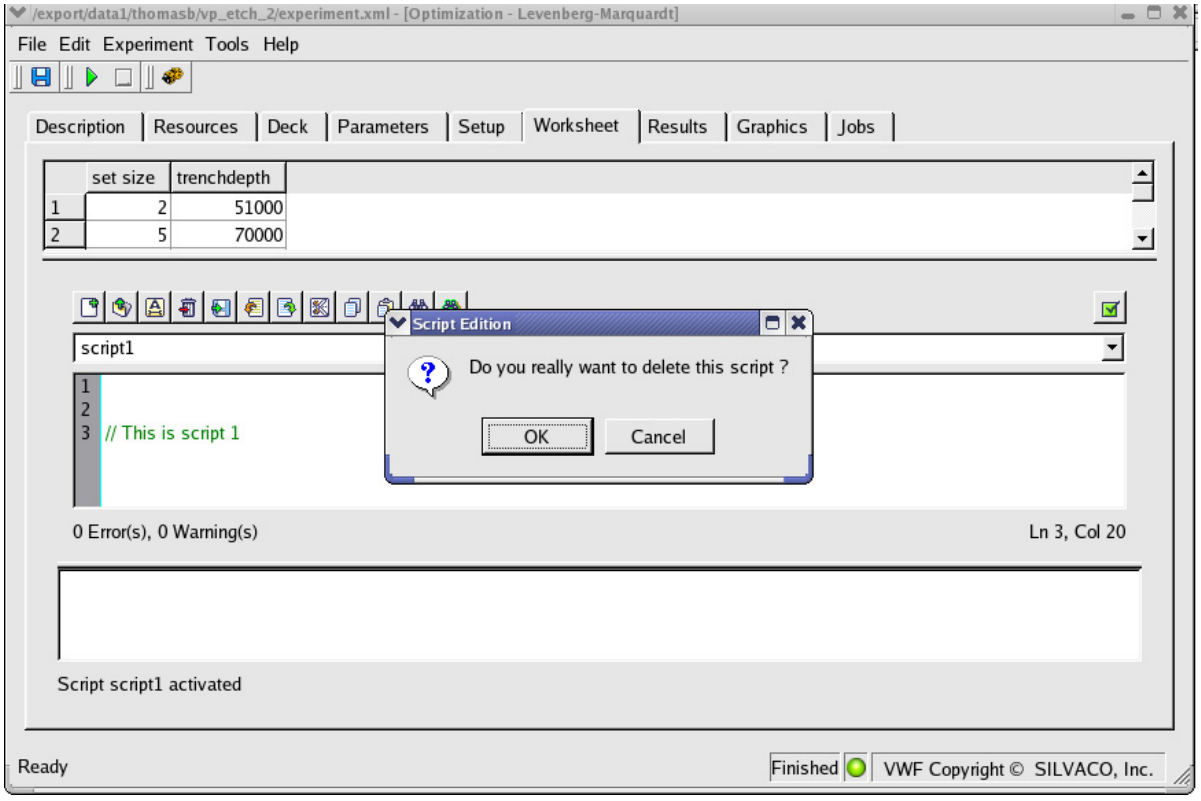


Figure 6-11 Deleting a Script

Saving a Script to Hard Disk

Figure 6-12 shows how a script can be saved on the hard disk (fifth button from left).

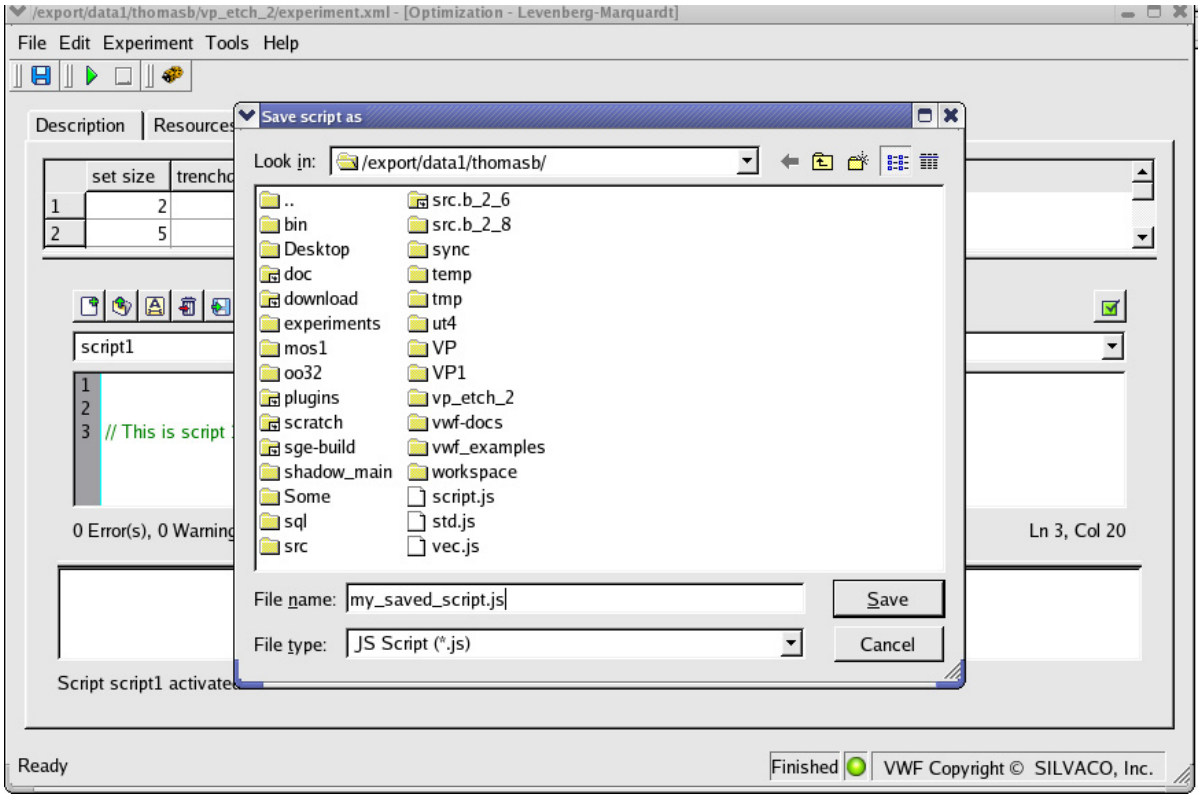


Figure 6-12 Saving a Target Script to Hard Disk

Undo

Allows you to undo a previous edit operation.

Redo

Allows you to repeat a previous edit operation.

Cut

Cuts highlighted text from the editor and copies it into the internal buffer.

Copy

Copies highlighted text from the editor into the internal buffer.

Paste

Pastes text from the internal buffer into the editor at the position of the cursor.

Find

Allows you to search for text.

Replace

Allows you to replace occurrences of text in the editor with another text.

Check

This is the right-most button. It allows you to debug the active script. The debug operation consists of compiling and running the script with some pre-defined values. The output of the check operation is then shown in the bottom most part of the worksheet pane. The screen-shot in Figure 6-13 illustrates the check operation. It shows an error in line 4. A non-existant variable (`target1`) was referenced. The output shows there was an error in the script:

```
(4): ReferenceError: target1 is not defined
```

The error indicates that there is a problem in line 4 of the script. If this script was run in an optimization experiment, the error would stop the optimization after the first iteration was finished. Given that simulations can take a comparably long time to finish, the error could be undetected for a while. It is thus advisable to always check a script when it is first loaded or whenever it is edited.

When there are no errors, then the output of the script consists only of outputs from `print_console` statements (see also Chapter 7 “Scripting in VWF”). Figure 6-14 shows how an error free check will look.

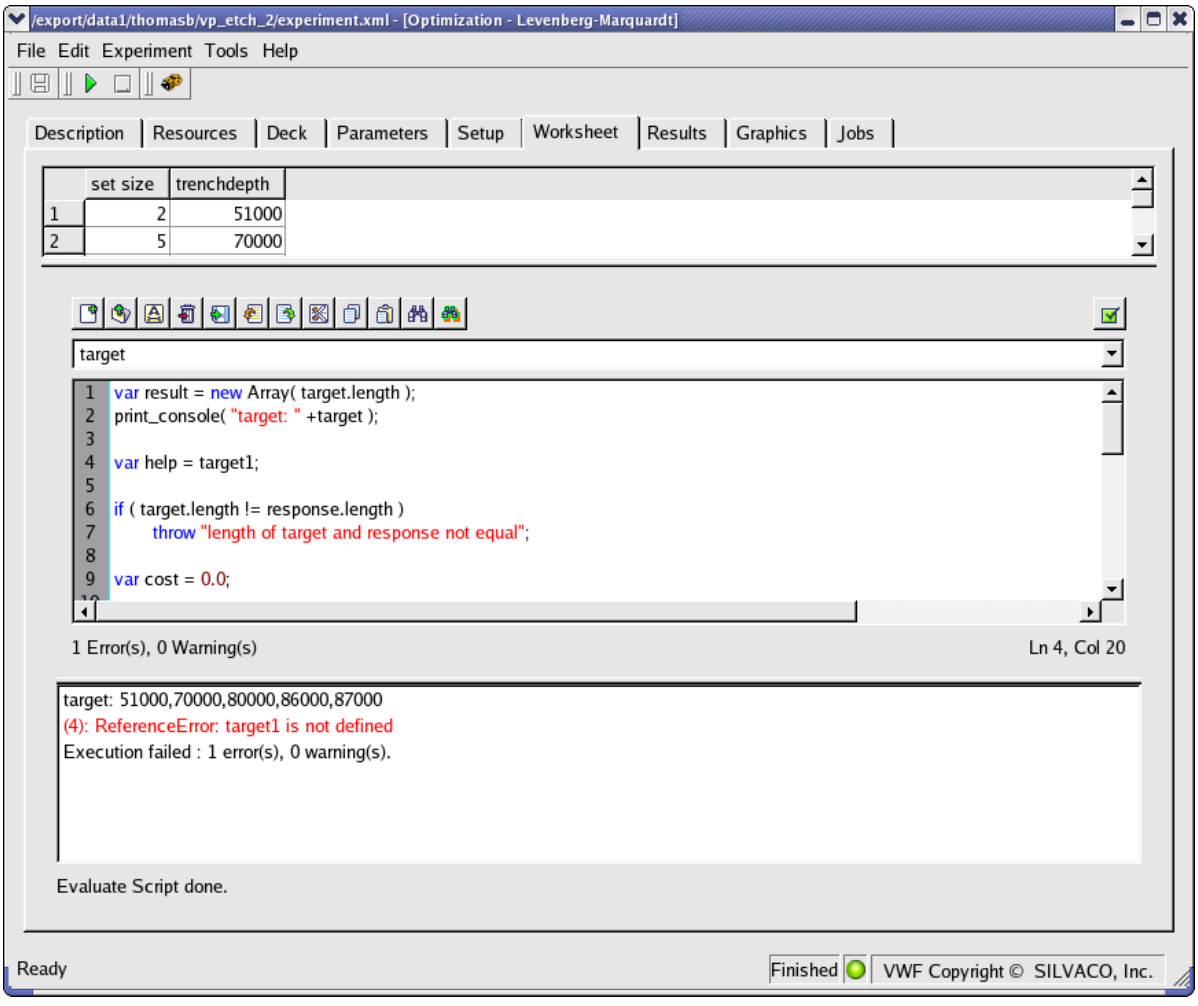

/export/data1/thomasb/vp_etch_2/experiment.xml - [Optimization - Levenberg-Marquardt]
File Edit Experiment Tools Help
Description Resources Deck Parameters Setup Worksheet Results Graphics Jobs
set size trenchdepth
1 2 51000
2 5 70000
target
1 var result = new Array(target.length);
2 print_console("target: " +target);
3
4 var help = target1;
5
6 if (target.length != response.length)
7 throw "length of target and response not equal";
8
9 var cost = 0.0;
1 Error(s), 0 Warning(s)
Ln 4, Col 20
target: 51000,70000,80000,86000,87000
(4): ReferenceError: target1 is not defined
Execution failed : 1 error(s), 0 warning(s).
Evaluate Script done.
Ready
Finished
VWF Copyright © SILVACO, Inc.

Figure 6-13 Checking the Target Script

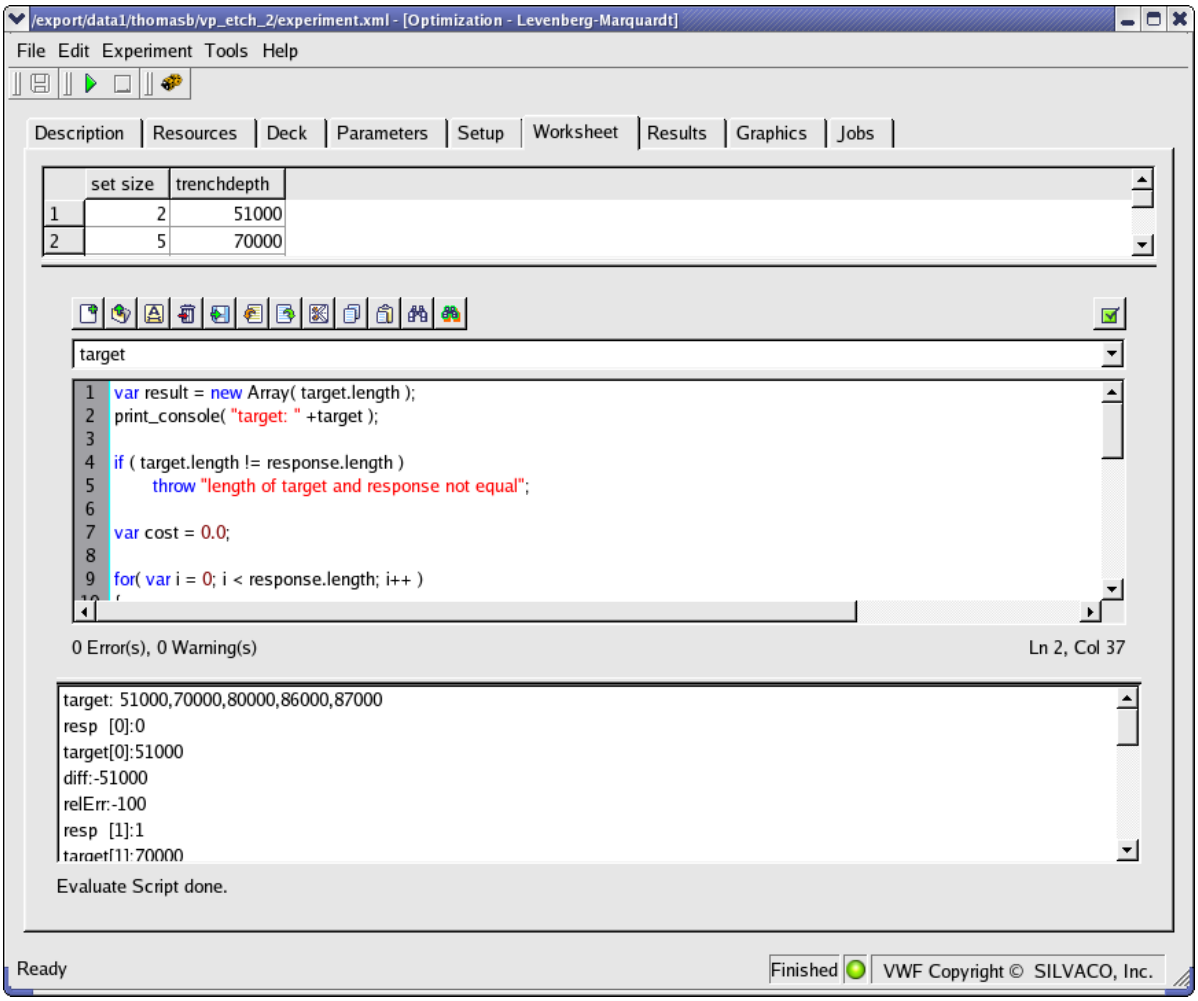


Figure 6-14 No Errors Detected by Target Script Check

6.6.2 Optimizer Convergence

It cannot generally be told in advance whether an optimization problem will have a solution. For instance, it is possible that the target value cannot be achieved by varying the parameters within the given bounds. This can happen if the parameters have no (or little) impact on the extracted value or if the parameter boundaries were chosen too narrow.

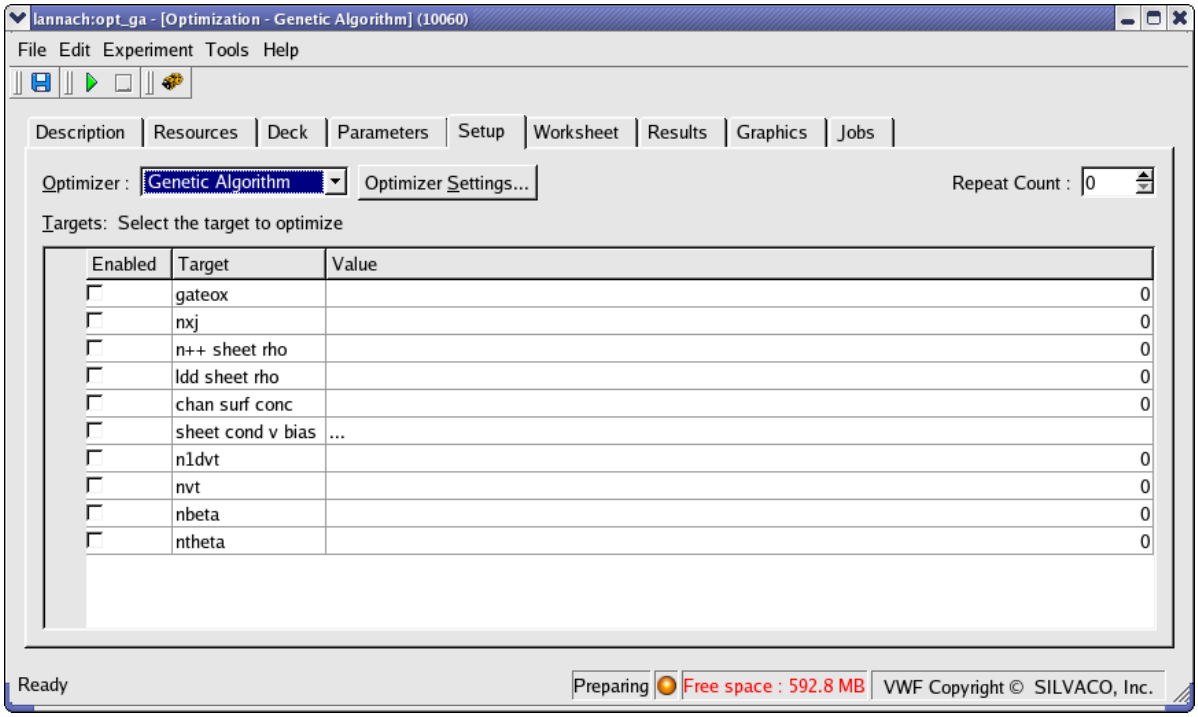


Figure 6-15 Optimizer Setup

The different ways of defining the target will be shown below.

6.6.3 Defining Optimizer Settings

When you select the **Optimizer Settings** button of Figure 6-15, the window shown in Figure 6-16 will open. Here, the various settings of the chosen optimization algorithm can be changed. Every optimizer will have different settings to tune. For instance, the shown genetic algorithm type optimizer offers settings **Population Size** or **Mutation Probability**.

The optimizer settings are not to be confused with the parameter definition (above). In the parameter definition you decide, which parameters are varied whereas the settings influence, how the parameters are varied and how the optimization proceeds. For instance, the mentioned population size parameter has an impact on how many simulations can be run at the same time (in parallel). The value of 50 as shown here will result in 50 simulations being queued and simulated. When the simulations are finished, the optimizer retrieves the results and chooses 50 more simulations until a truncation criterion is finally reached. Therefore, it can be noted that the population size should not be set to a too small value. For instance, if the population size were reduced to a value of 2, then only two simulations would be carried out at a time, even if you have a computing cluster with 50 or more CPUs available.

The optimal values for the settings strongly depend on the situation at hand and need to be tailored to your specific needs. Sensible default values are given, which allow you to start an experiment right away with the possibility to tune this at a later time.

The button **Use Settings from Preferences** allows you to revert to the default values as stored in your preferences file. This can be useful if you accidentally modified a setting or can't remember the default value.

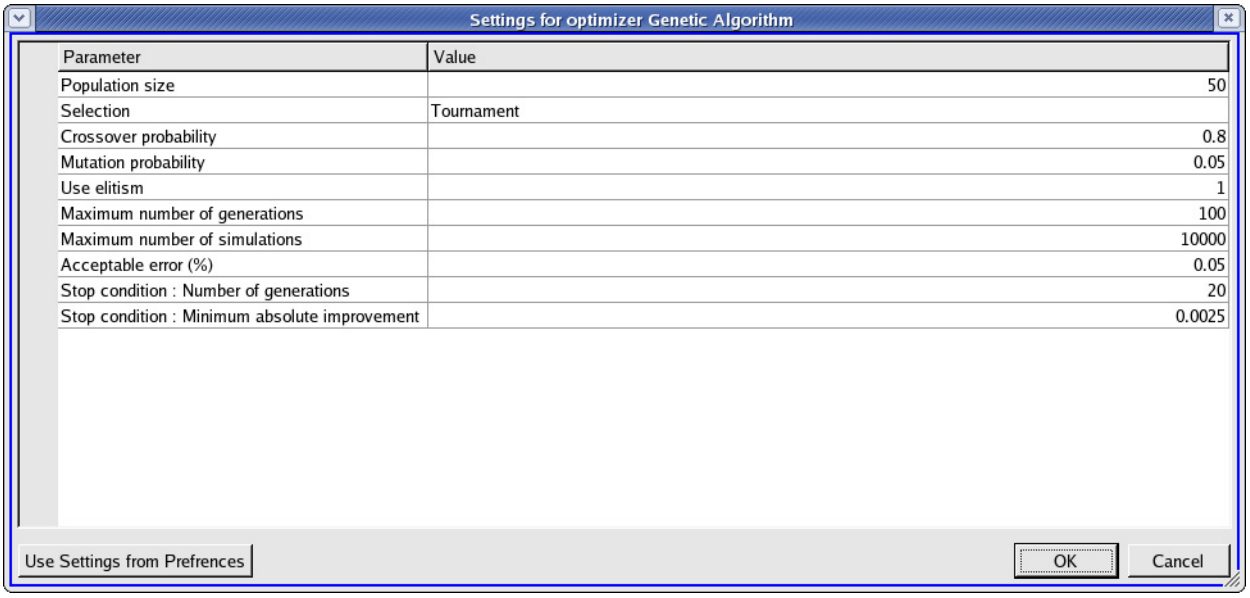


Figure 6-16 Optimizer Settings

6.6.4 Defining Scalar Targets

In the following, it will be shown how a scalar target can be defined. Figure 6-17 shows the selection of a scalar value (the threshold voltage of a MOS transistor – `nvt`) is selected as target. Additionally, a target value to achieve was entered (a value of `0.65`).

The effect of this setup is now that VWF internally subtracts `0.65` from the extracted `nvt` value and passes the absolute value of that difference as target to the optimizer. The optimizer is now setup to find a parameter combination for the defined parameters `dose` and `energy` within the given bounds to reach a value of exactly `0.65V` for `nvt`.

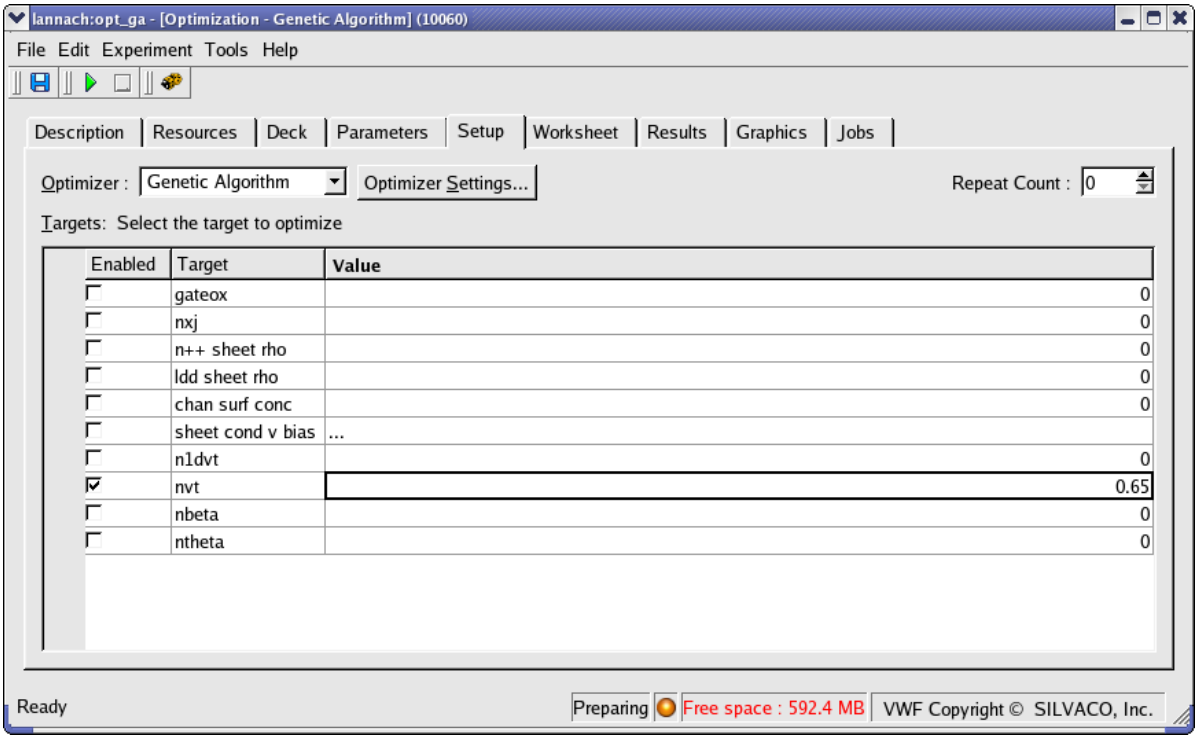


Figure 6-17 Entering a Scalar Target Value

With the completion of the target definition, the optimization experiment is now fully defined and ready to be started. This is done in exactly the same way as for a DOE type experiment by clicking . Jobs are queued immediately after the button was pressed. The **Results** tab will look similar to Figure 6-18. In Figure 6-18, no results have been obtained so far as the experiment was just started. There is one extra column called **cost**, which does not correspond to any extracted response. Instead, the cost is a root mean square of the error vector (in case of a vector target) or a copy of the target (for scalar target values). If a JavaScript target script is used to compute the target, the cost can also be computed in the script, overriding the default implementation.

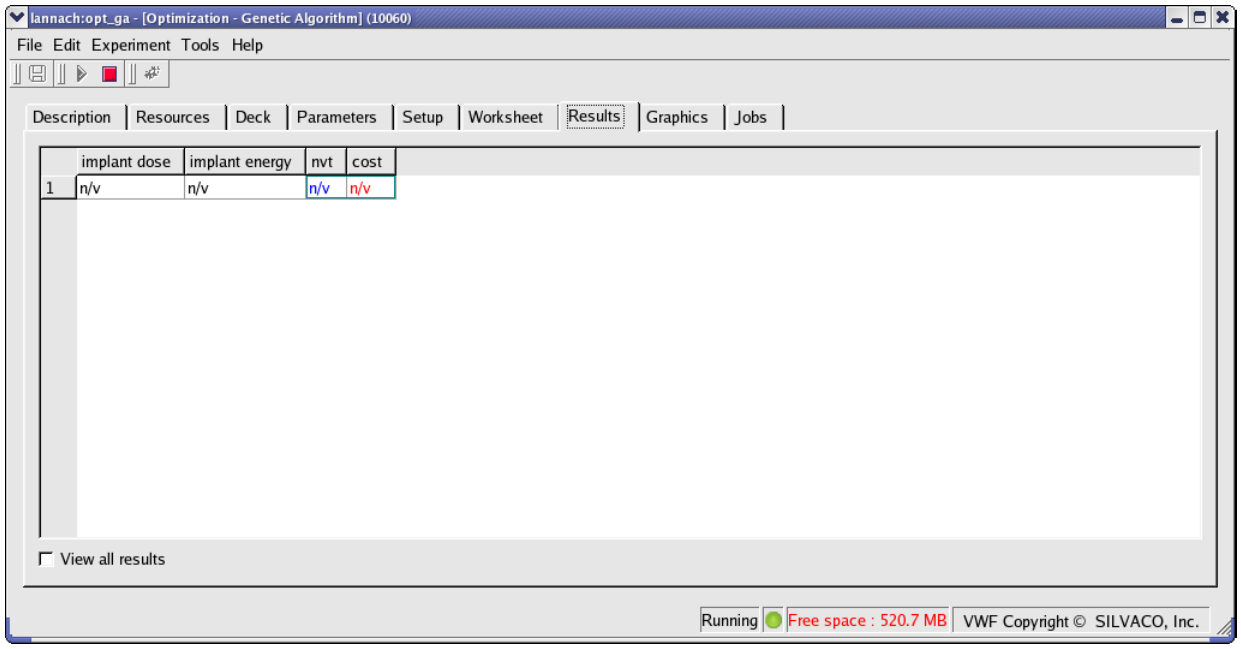
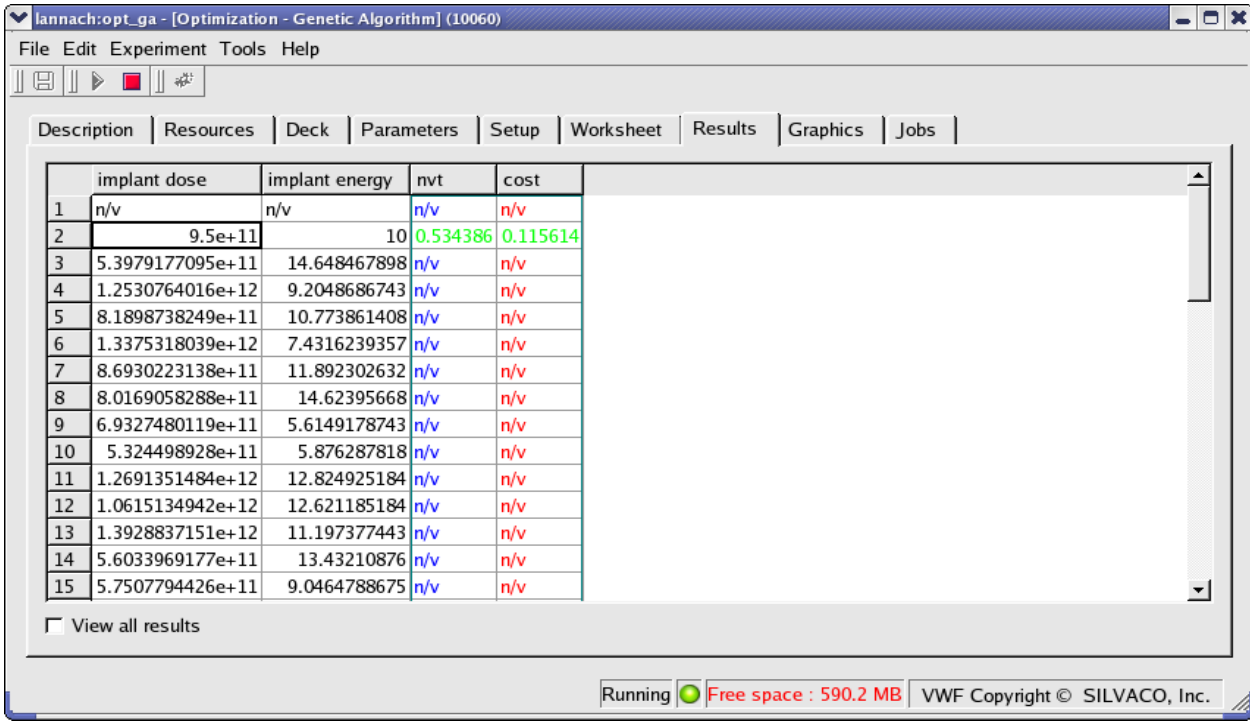


Figure 6-18 Started Optimization Experiment

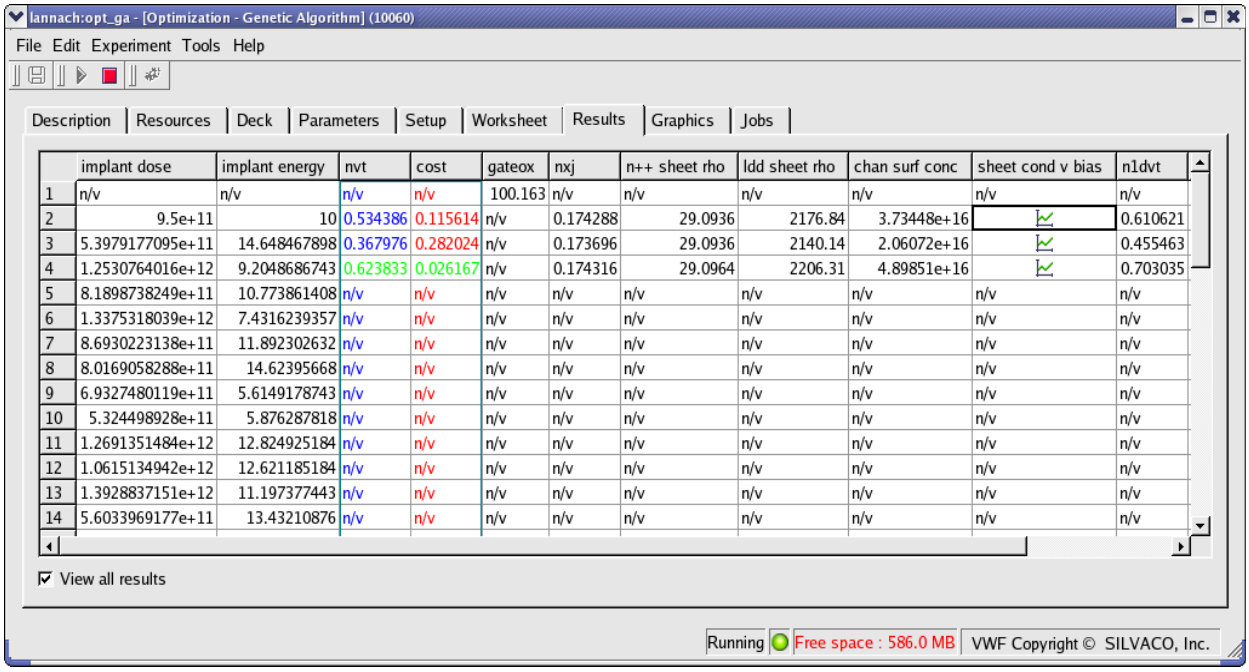
Figure 6-19 depicts the situation where one simulation job is finished and others have been queued and are waiting to become activated by the queuing system. The best target/cost so far is drawn in green color. Here, the best achieved target value so far was found for a `dose` and `energy` of `9.5e11` and `10` respectively and is `0.53V`. The displayed cost value is ~0.12, which is the deviation of the computed (0.53V) from the entered target (0.65V) voltage. Here, no JavaScript target script is used.


lannach:opt_ga - [Optimization - Genetic Algorithm] (10060)
File Edit Experiment Tools Help
Description Resources Deck Parameters Setup Worksheet Results Graphics Jobs
View all results
Running
Free space : 590.2 MB
VWF Copyright © SILVACO, Inc.

	implant dose	implant energy	nvt	cost
1	n/v	n/v	n/v	n/v
2	9.5e+11	10	0.534386	0.115614
3	5.3979177095e+11	14.648467898	n/v	n/v
4	1.2530764016e+12	9.2048686743	n/v	n/v
5	8.1898738249e+11	10.773861408	n/v	n/v
6	1.3375318039e+12	7.4316239357	n/v	n/v
7	8.6930223138e+11	11.892302632	n/v	n/v
8	8.0169058288e+11	14.62395668	n/v	n/v
9	6.9327480119e+11	5.6149178743	n/v	n/v
10	5.324498928e+11	5.876287818	n/v	n/v
11	1.2691351484e+12	12.824925184	n/v	n/v
12	1.0615134942e+12	12.621185184	n/v	n/v
13	1.3928837151e+12	11.197377443	n/v	n/v
14	5.6033969177e+11	13.43210876	n/v	n/v
15	5.7507794426e+11	9.0464788675	n/v	n/v

Figure 6-19 Optimization Running

When the **View all results** box at the bottom left corner is not checked, only the selected target is shown in the **Results** pane. Once the box is checked, all remaining extracted values (responses) are shown. This is shown in Figure 6-20. For the response named "`sheet cond v bias`", a small icon is shown instead of a value. This is because this response is a vector and not a scalar. Double-clicking on the icon will open another window displaying the vector (see Figure 6-21).


lannach:opt_ga - [Optimization - Genetic Algorithm] (10060)
File Edit Experiment Tools Help
Description Resources Deck Parameters Setup Worksheet Results Graphics Jobs
View all results
Running
Free space : 586.0 MB
VWF Copyright © SILVACO, Inc.

	implant dose	implant energy	nvt	cost	gateox	nxj	n++ sheet rho	ldd sheet rho	chan surf conc	sheet cond v bias	n1dvt
1	n/v	n/v	n/v	n/v	100.163	n/v	n/v	n/v	n/v	n/v	n/v
2	9.5e+11	10	0.534386	0.115614	n/v	0.174288	29.0936	2176.84	3.73448e+16		0.610621
3	5.3979177095e+11	14.648467898	0.367976	0.282024	n/v	0.173696	29.0936	2140.14	2.06072e+16		0.455463
4	1.2530764016e+12	9.2048686743	0.623833	0.026167	n/v	0.174316	29.0964	2206.31	4.89851e+16		0.703035
5	8.1898738249e+11	10.773861408	n/v	n/v	n/v	n/v	n/v	n/v	n/v	n/v	n/v
6	1.3375318039e+12	7.4316239357	n/v	n/v	n/v	n/v	n/v	n/v	n/v	n/v	n/v
7	8.6930223138e+11	11.892302632	n/v	n/v	n/v	n/v	n/v	n/v	n/v	n/v	n/v
8	8.0169058288e+11	14.62395668	n/v	n/v	n/v	n/v	n/v	n/v	n/v	n/v	n/v
9	6.9327480119e+11	5.6149178743	n/v	n/v	n/v	n/v	n/v	n/v	n/v	n/v	n/v
10	5.324498928e+11	5.876287818	n/v	n/v	n/v	n/v	n/v	n/v	n/v	n/v	n/v
11	1.2691351484e+12	12.824925184	n/v	n/v	n/v	n/v	n/v	n/v	n/v	n/v	n/v
12	1.0615134942e+12	12.621185184	n/v	n/v	n/v	n/v	n/v	n/v	n/v	n/v	n/v
13	1.3928837151e+12	11.197377443	n/v	n/v	n/v	n/v	n/v	n/v	n/v	n/v	n/v
14	5.6033969177e+11	13.43210876	n/v	n/v	n/v	n/v	n/v	n/v	n/v	n/v	n/v

Figure 6-20 All Extracts Shown

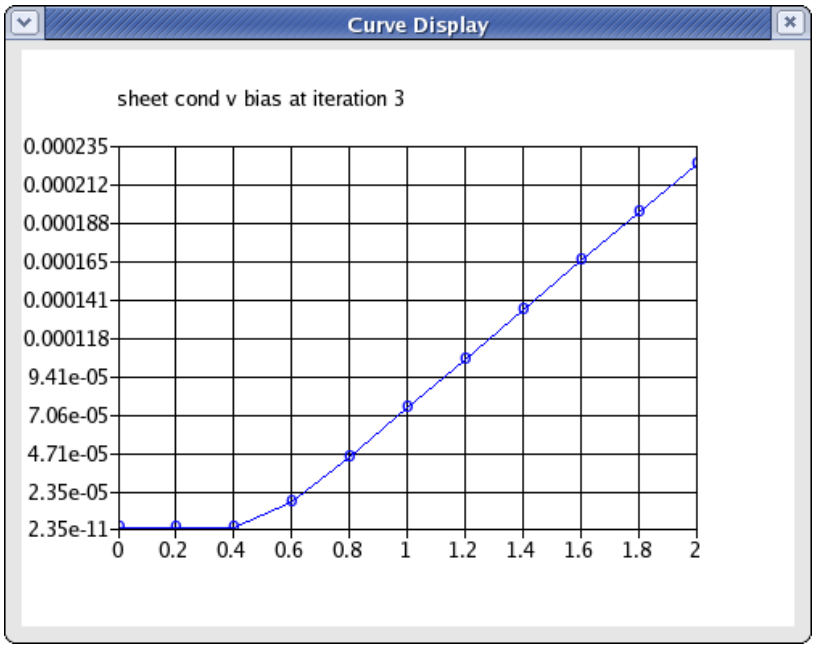
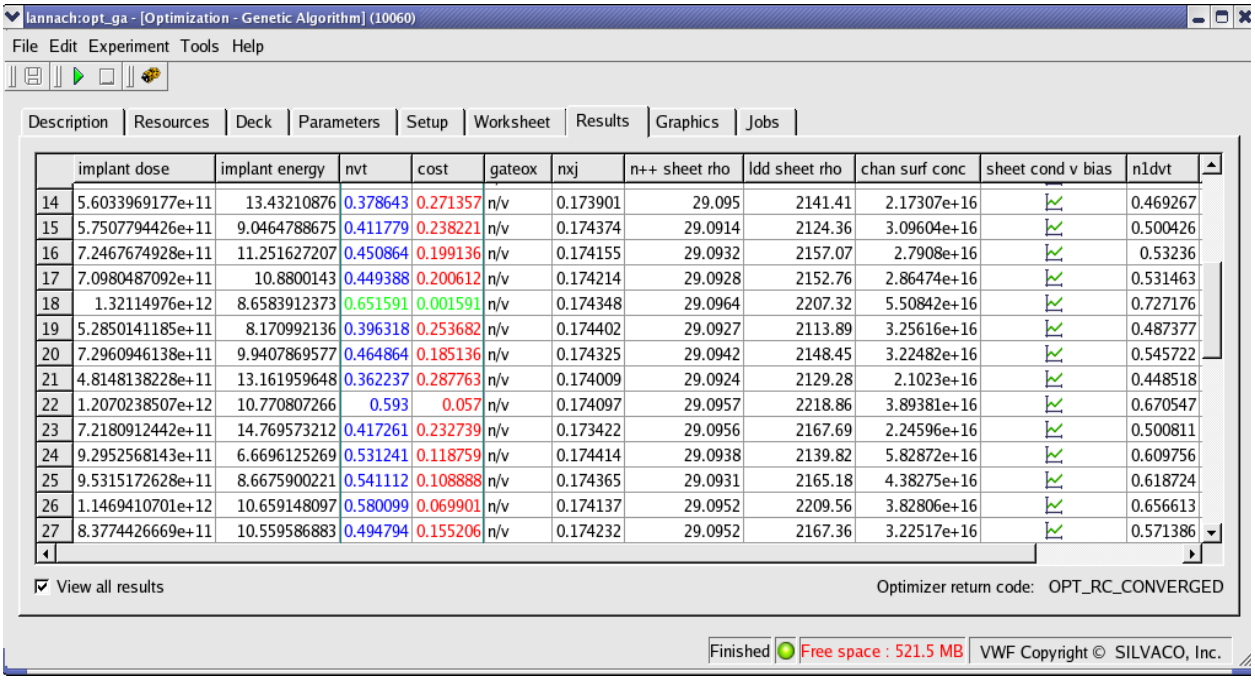


Figure 6-21 Viewing a Vector Response

Figure 6-22 depicts the **Results** tab after the experiment was finished. You can see that the experiment is no longer running by looking at the status light (LED shaped) at the bottom of the experiment window. The status has changed from "Running" to "Finished". The status of the optimization is shown at the bottom on the right-hand side. The optimizer has returned with OPT_RC_CONVERGED. This means that the target value could be reached within the given error criterion. The best target value is shown in green and the parameter combinations can be found next to the best target. Here, the values of 1.32e12 and 8.66 for parameters dose and energy were found to lead to a value of 0.652V for nvt and give a cost value of 0.001. Please refer to Section 6.6.7 "Optimizer Return Codes" for a description of all possible optimizer return codes.


lannach:opt_ga - [Optimization - Genetic Algorithm] (10060)
File Edit Experiment Tools Help
Description Resources Deck Parameters Setup Worksheet Results Graphics Jobs
View all results
Optimizer return code: OPT_RC_CONVERGED
Finished
Free space : 521.5 MB
VWF Copyright © SILVACO, Inc.

	implant dose	implant energy	nvt	cost	gateox	nxj	n++ sheet rho	ldd sheet rho	chan surf conc	sheet cond v bias	n1dvt
14	5.6033969177e+11	13.43210876	0.378643	0.271357	n/v	0.173901	29.095	2141.41	2.17307e+16		0.469267
15	5.7507794426e+11	9.0464788675	0.411779	0.238221	n/v	0.174374	29.0914	2124.36	3.09604e+16		0.500426
16	7.2467674928e+11	11.251627207	0.450864	0.199136	n/v	0.174155	29.0932	2157.07	2.7908e+16		0.53236
17	7.0980487092e+11	10.8800143	0.449388	0.200612	n/v	0.174214	29.0928	2152.76	2.86474e+16		0.531463
18	1.32114976e+12	8.6583912373	0.651591	0.001591	n/v	0.174348	29.0964	2207.32	5.50842e+16		0.727176
19	5.2850141185e+11	8.170992136	0.396318	0.253682	n/v	0.174402	29.0927	2113.89	3.25616e+16		0.487377
20	7.2960946138e+11	9.9407869577	0.464864	0.185136	n/v	0.174325	29.0942	2148.45	3.22482e+16		0.545722
21	4.8148138228e+11	13.161959648	0.362237	0.287763	n/v	0.174009	29.0924	2129.28	2.1023e+16		0.448518
22	1.2070238507e+12	10.770807266	0.593	0.057	n/v	0.174097	29.0957	2218.86	3.89381e+16		0.670547
23	7.2180912442e+11	14.769573212	0.417261	0.232739	n/v	0.173422	29.0956	2167.69	2.24596e+16		0.500811
24	9.2952568143e+11	6.6696125269	0.531241	0.118759	n/v	0.174414	29.0938	2139.82	5.82872e+16		0.609756
25	9.5315172628e+11	8.6675900221	0.541112	0.108888	n/v	0.174365	29.0931	2165.18	4.38275e+16		0.618724
26	1.1469410701e+12	10.659148097	0.580099	0.069901	n/v	0.174137	29.0952	2209.56	3.82806e+16		0.656613
27	8.3774426669e+11	10.559586883	0.494794	0.155206	n/v	0.174232	29.0952	2167.36	3.22517e+16		0.571386

Figure 6-22 Finished Optimization

Figure 6-23 shows the **Graphics** tab, which displays the progress of the target and cost values as the optimization proceeds. A dot is shown for every simulated parameter combination. As with the **Results** tab, the best cost so far is shown in green. In this example, this is the value at iteration number **18**.

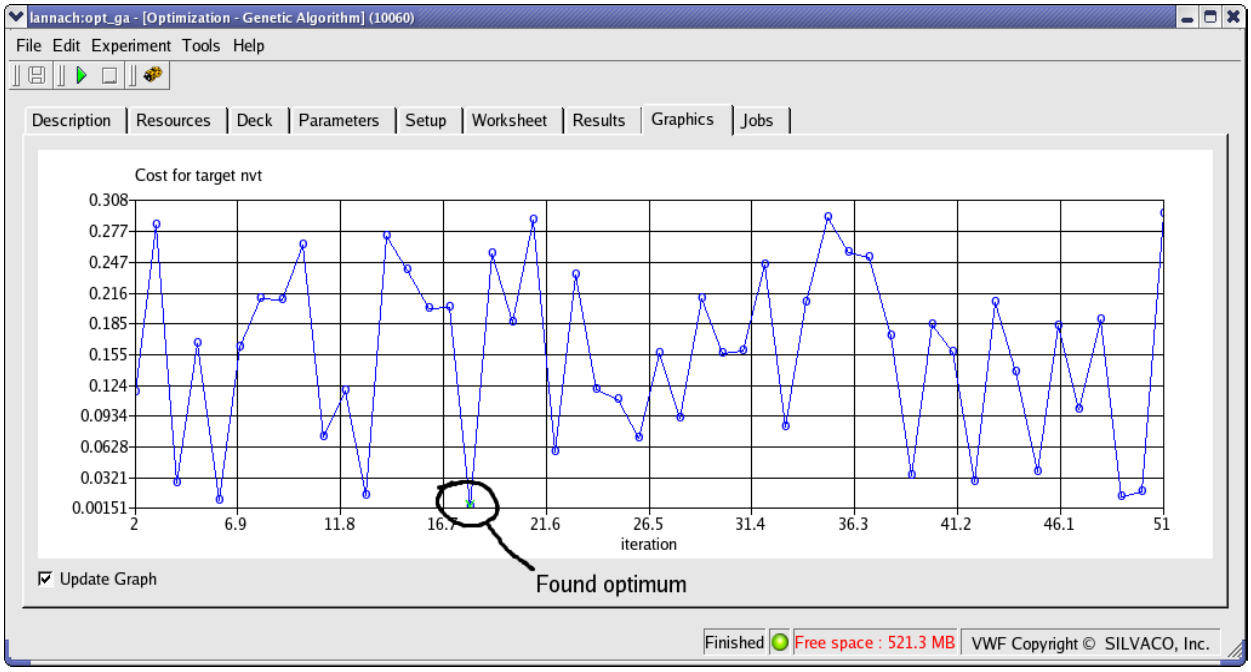


Figure 6-23 Target Progress

As with DOE type, experiments details can be shown for every simulation. To display the details of a given simulation, navigate to the **Results** tab and right-click on an entry. Select **results details** from the context menu. Figure 6-24 depicts the details for iteration number **7**.

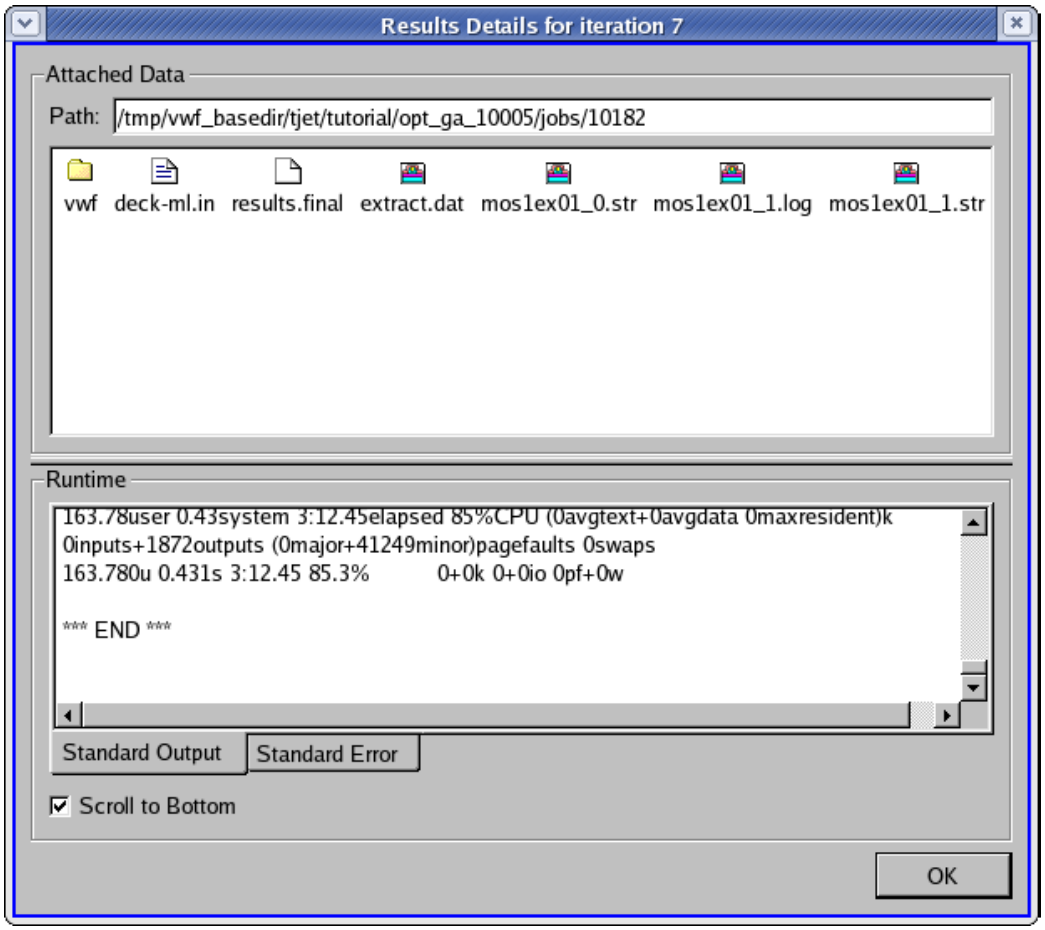


Figure 6-24 Result Details

6.6.5 Defining Vector Targets

Currently, only the Levenberg-Marquardt optimization algorithm supports vector targets. One of the main applications of this optimization type is fitting parameters by comparing two curves to each other. The comparison of the two curves takes place in the optimization algorithm, which uses a least-squares minimization scheme.

The simplest way of defining a vector target is to use a curve extract as shown in Figure 6-25. Figure 6-26 shows the selected curve target (IV) in the optimizer **Setup** tab.

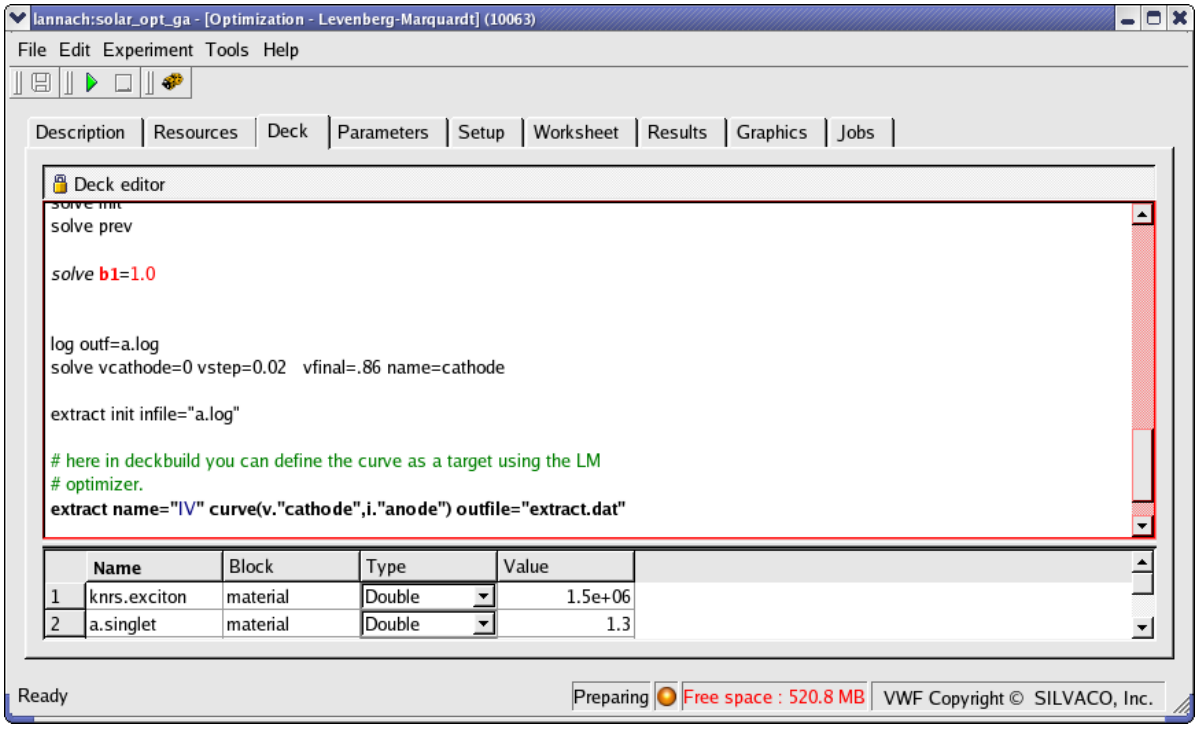

lannach:solar_opt_ga - [Optimization - Levenberg-Marquardt] (10063)
File Edit Experiment Tools Help
Description Resources Deck Parameters Setup Worksheet Results Graphics Jobs
Deck editor
solve prev
solve b1=1.0
log outf=a.log
solve vcathode=0 vstep=0.02 vfinal=.86 name=cathode
extract init infile="a.log"
here in deckbuild you can define the curve as a target using the LM
optimizer.
extract name="IV" curve(v."cathode",i."anode") outfile="extract.dat"
Name Block Type Value
1 knrs.exciton material Double 1.5e+06
2 a.singlet material Double 1.3
Ready
Preparing
Free space : 520.8 MB
VWF Copyright © SILVACO, Inc.

Figure 6-25 Curve Extract

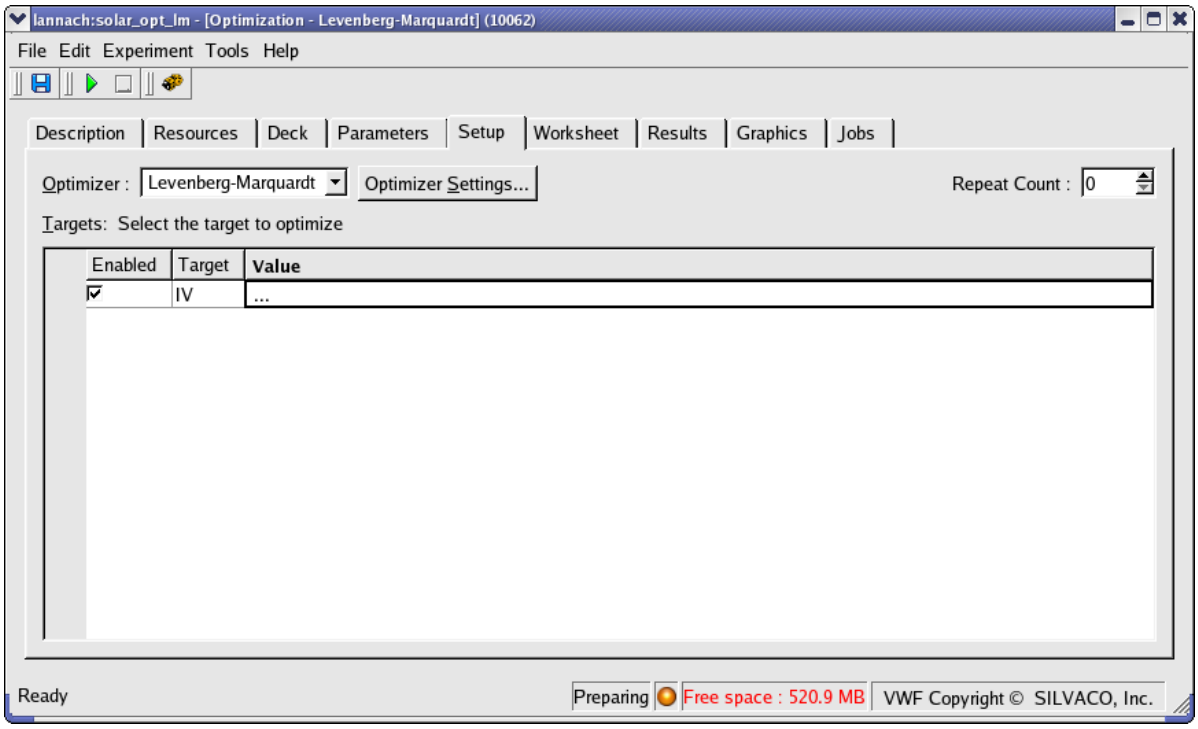

lannach:solar_opt_lm - [Optimization - Levenberg-Marquardt] (10062)
File Edit Experiment Tools Help
Description Resources Deck Parameters Setup Worksheet Results Graphics Jobs
Optimizer : Levenberg-Marquardt
Optimizer Settings...
Repeat Count : 0
Targets: Select the target to optimize
Enabled Target Value
IV ...
Ready
Preparing
Free space : 520.9 MB
VWF Copyright © SILVACO, Inc.

Figure 6-26 Selected Curve Target

Double-clicking on the **Value** column of the selected target opens the window shown in Figure 6-27. You can enter values manually or load them from another curve file. For instance, when you want to do a calibration, then you might want to load a measured curve from a file and use this as reference for the optimizer. The file-format that can be loaded is the format also understood by TonyPlot. Figure 6-28 shows the loaded (or manually entered) values for the vector target. The dialog allows to modify any of the loaded values. By clicking **OK**, they are taken over into the **Setup** pane (Figure 6-29). For every simulation, VWF takes the simulation result and computes a component-wise absolute error (the difference) of the simulated to the reference curve. The error vector is then passed on to the Levenberg-Marquardt optimizer.

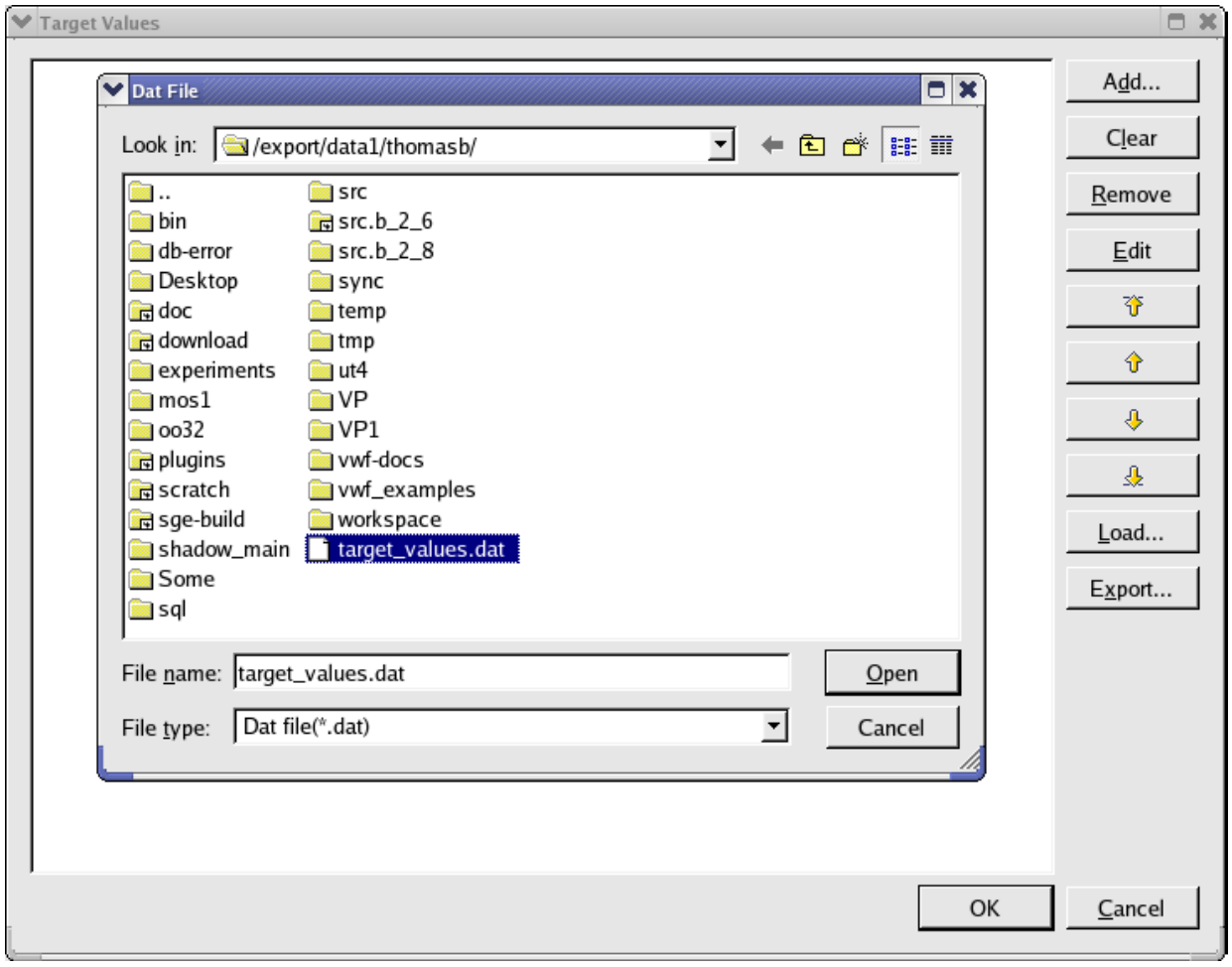


Figure 6-27 Vector Target Value Definition

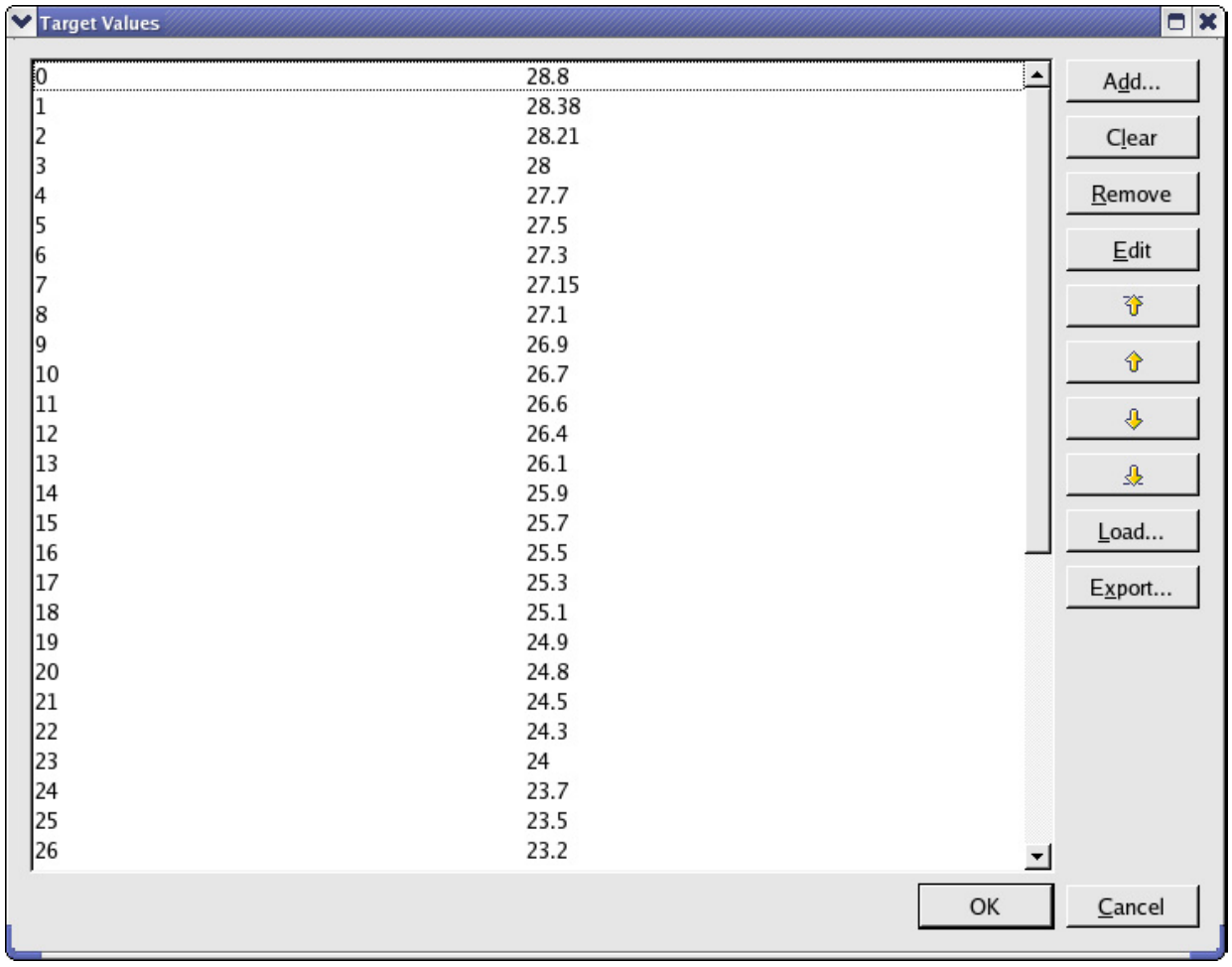


Figure 6-28 Loaded or Entered Vector Target Values

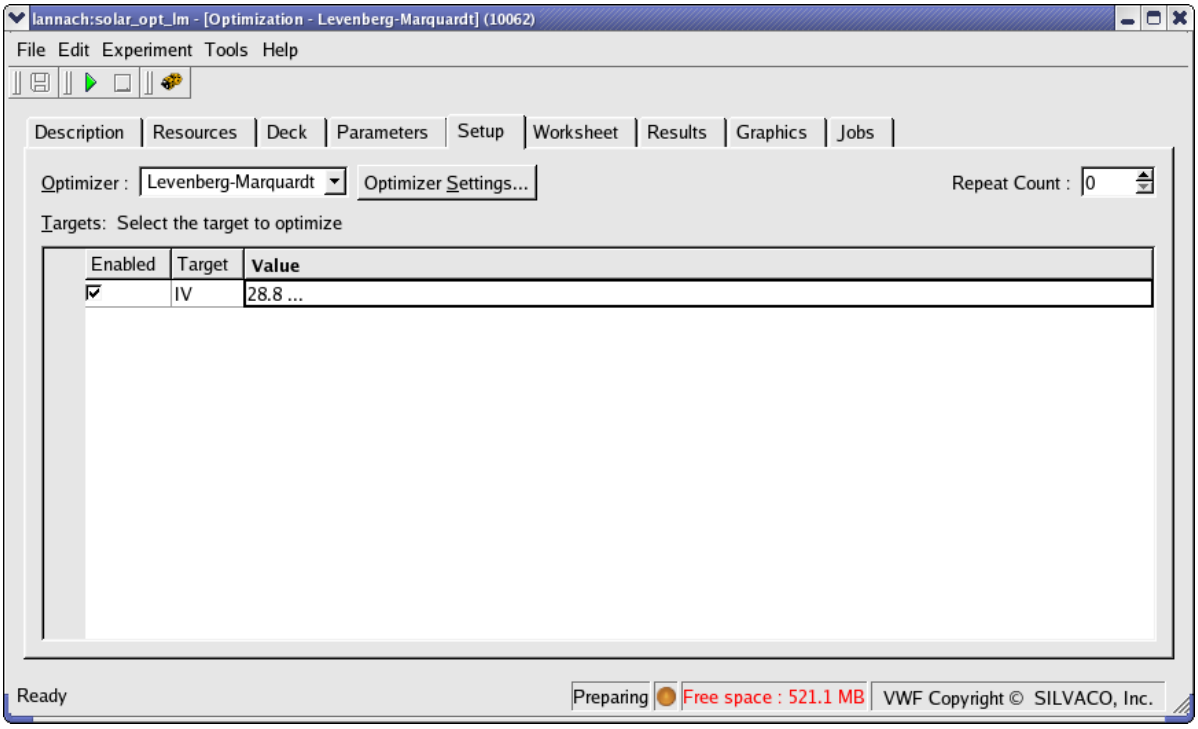


Figure 6-29 Defined Vector Target Values

6.6.6 Target Definition Language

VWF can use the DBInternal simulator to define both vector and scalar targets. This is particularly useful if some computations will be performed, which deviate from the standard default VWF internal implementation. The computations are performed using the `evalmath` language of DBInternal. In the following, a short example is given. It creates a variable called `rel_err` from two curves read from files `ref_curve.dat` and `extract.dat`:

```
go internal
# read curves into variables for use in evalmath statements
read vector name=id_vd_ref file=ref_curve.dat
read vector name=id_vd_sim file=extract.dat


evalmath result=rel_err file=target.dat


# compute a relative error, assume there are no '0' values in ref
curve
help := ( $id_vd_sim - $id_vd_ref ) / $id_vd_ref


# compute dot product (square), divide by length of vector
# and take square-root thereof
# The result is assigned to the result variable (rel_err) and
stored
# in file target.dat
Sqrt( * help . help / Length( help ) )
endeval
```

The target language of DBInternal supports the following built in functions and operators:

- `Sqrt` - computes the square root of a scalar value or of all elements of a vector
- `Ln` - computes the logarithm of a scalar value or of all elements of a vector
- `Abs` - computes the absolute value of a scalar or of all elements of a vector
- `Length` - returns the dimension of a vector
- `Dot (.)` - computes the dot product of two vectors
- `+,-,*,/` - operators for two scalars or two vectors (element-wise)

To use the computed result `rel_err` as a target in VWF, you must enter an additional `extract` statement after the `evalmath` section (after the `endeval` statement).

```
# define a dummy extract in order to make rel_err available in VWF.
extract name="rel_err" outfile="target.dat"
```

This `extract` statement will tell VWF that there is a target called `rel_err`, which is found in the file name `target.dat`.

6.6.7 Optimizer Return Codes

An optimization will finish with one of the following return codes:

- OPT_RC_CONVERGED - The best cost obtained is less than the specified tolerance.
- OPT_RC_INCONSISTENT_BOUNDS - At least one of the optimization parameterslies outside the defined limits.
- OPT_RC_INCONSISTENT_INPUT - The optimization parameters lower bounds, and upper bounds arrays are not of the same length.
- OPT_RC_INVALID_CROSS_PROB - The crossover probability specified for a GA or DE optimization is outside of its valid range of 0 to 1.
- OPT_RC_INVALID_STOPPER_DROP - The first stopper parameter (the analogous function for PT, GA or DE) is negative.
- OPT_RC_INVALID_STOPPER_STEPS - The second stopper parameter (the analogous function for PT, GA, or DE) is zero. It must be at least 1.
- OPT_RC_INVALID_TOL - The tolerance specified is negative.
- OPT_RC_LOW_POPULATION - The population size specified for a GA or DE optimization is less than the minimum value allowed, which is 6.
- OPT_RC_MAX_FUNC_EVALS - The specified maximum number of simulations has been reached.
- OPT_RC_MAX_GENERATIONS - The specified maximum number of generations for a GA or DE optimization has been reached.
- OPT_RC_NOT_ENOUGH_IMPROVEMENT - The cost did not improve between two steps of the optimization algorithm.
- OPT_RC_NOTHING_TO_OPTIMIZE - No parameters to optimizer have been specified
- OPT_RC_USER_TERMINATED - The optimization has been terminated on the user's request.
- OPT_RC_UNKNOWN_ERROR - The optimization terminated but no cause could be diagnosed. Any appearance of this value probably indicates the presence of a bug.
- OPT_RC_LM_WRONG_INPUT - The input to the underlying Levenberg-Marquardt routine was not acceptable.
- OPT_RC_LM_INVALID_JAC_FACTOR - The Jacobian factor was not greater than machine epsilon.
- OPT_RC_HJ_INVALID_STEP_FACTOR - The stepsize factor specified for a HJ optimization is outside of its valid range of 0 to 1.
- OPT_RC_HJ_MAX_ITERATIONS - The specified maximum number of iterations in a HJ optimization has been reached
- OPT_RC_SA_BELOW_MIN_TEMP - The specified minimum temperature in a SA optimization has been reached.
- OPT_RC_SA_INVALID_COOL_FACTOR - The cooling factor specified for a SA optimization is outside of its valid range of 0 to 1.
- OPT_RC_SA_INVALID_START_TEMP - The starting temperature value specified for a SA optimization is not strictly positive.
- OPT_RC_PT_MAX_CYCLES - The specified maximum number of cycles in a PT optimization has been reached.

- `OPT_RC_PT_BAD_TEMP_RANGE` - The temperature range specified for a PT optimization is invalid. The maximum temperature must be strictly greater than the minimum temperature and the minimum temperature must be strictly greater than zero.
- `OPT_RC_GA_INVALID_MUTE_PROB` - The mutation probability specified for a GA optimization is outside of its valid range of 0 to 1.
- `OPT_RC_GA_ODD_POPSIZE` - The population size specified for a GA optimization is not even.
- `OPT_RC_DE_INVALID_AMP_FACT` - The amplification factor specified for a DE optimization is outside of its valid range of 0 to 1.

6.7 Optimization Example: Advanced Calibration Task

In this section, an example is presented to demonstrate the setup of an advanced calibration task carried out with the Victory Process simulator. This example is also available from the examples shipped with VWF. The optimization task consists of the calibration of a 3D ion enhanced chemical etching (IECE) model of Victory Process. The model will be calibrated to measured data for various mask openings as published in [1].

The measurements are available as the experimentally achieved trench depths after 60 seconds of applied chemical etching. The depths are given for 5 different mask widths.

Table 6-1 Trench depths for 5 mask widths

Width [um]	Trench depth [angstrom]
2	51000
5	70000
10	80000
17	86000
20	87000

The parameters to calibrate are the neutral rate and ratio. The parameters will be tuned by the optimizer to achieve minimal deviation from measurement.

To setup this experiment, start by defining a Levenberg-Marquardt optimization experiment based on the deck depicted in Figure 6-30.

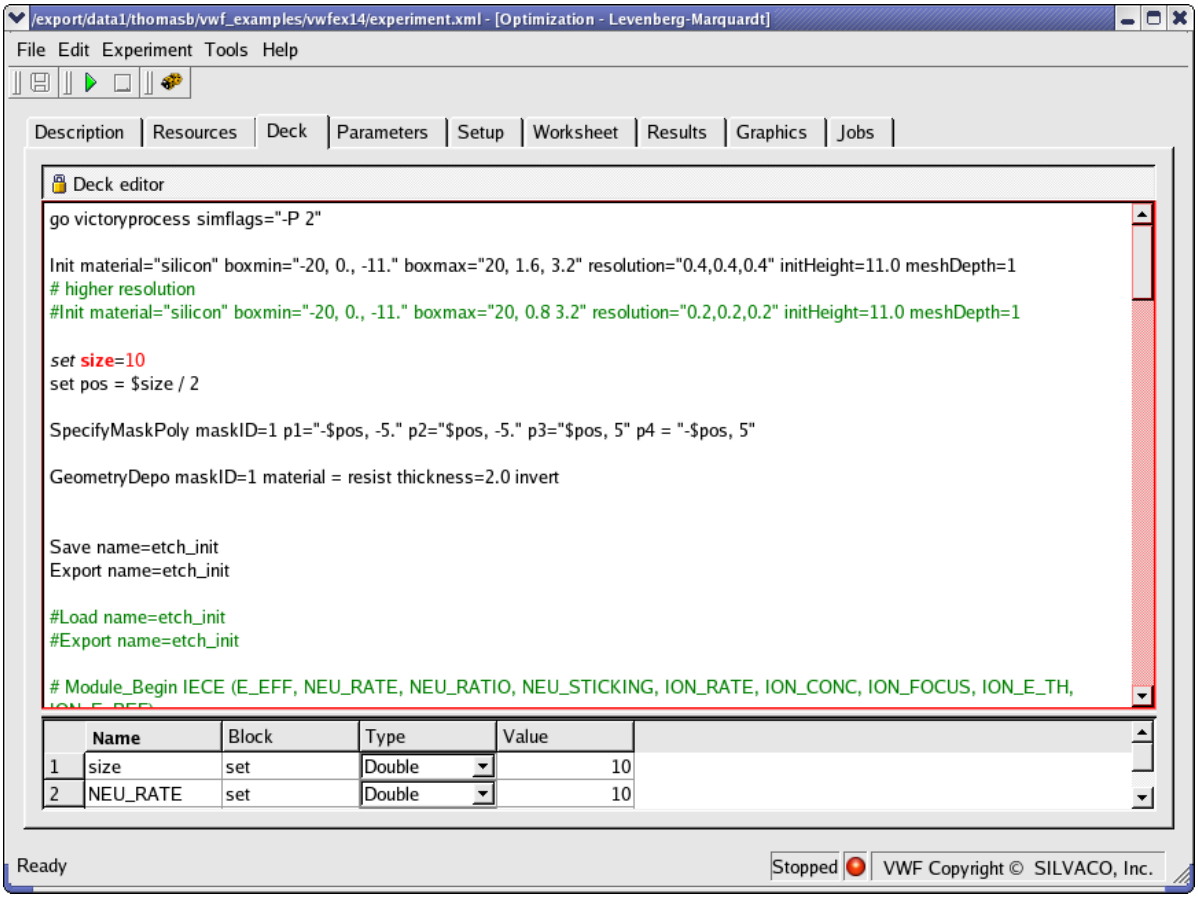

/export/data1/thomasb/vwf_examples/vwfex14/experiment.xml - [Optimization - Levenberg-Marquardt]
File Edit Experiment Tools Help
Description Resources Deck Parameters Setup Worksheet Results Graphics Jobs
Deck editor
go victoryprocess simflags="-P 2"
Init material="silicon" boxmin="-20, 0., -11." boxmax="20, 1.6, 3.2" resolution="0.4,0.4,0.4" initHeight=11.0 meshDepth=1
higher resolution
#Init material="silicon" boxmin="-20, 0., -11." boxmax="20, 0.8 3.2" resolution="0.2,0.2,0.2" initHeight=11.0 meshDepth=1
set size=10
set pos = $size / 2
SpecifyMaskPoly maskID=1 p1="-$pos, -5." p2="$pos, -5." p3="$pos, 5" p4 = "-$pos, 5"
GeometryDepo maskID=1 material = resist thickness=2.0 invert
Save name=etch_init
Export name=etch_init
#Load name=etch_init
#Export name=etch_init
Module_Begin IECE (E_EFF, NEU_RATE, NEU_RATIO, NEU_STICKING, ION_RATE, ION_CONC, ION_FOCUS, ION_E_TH,
Name Block Type Value
1 size set Double 10
2 NEU_RATE set Double 10
Ready
Stopped
VWF Copyright © SILVACO, Inc.

Figure 6-30 Victory Process deck to calibrate

Select the parameters to vary. Identify which parameters are used by the optimizers and which you want to use to define a DOE tree. Figure 6-31 depicts the parameters pane with 3 parameters selected. The column named DOE is used to distinguish DOE parameters (checked) from optimization parameters (unchecked). The shown setup will tune the parameters named `set NEU_RATE` and `set NEU_RATIO` using the optimizer, whereas the parameter named `set size` is used to define target values. Target values will be entered in the worksheet pane (see below). Finally, you can define lower and upper bounds for each parameter as well as the initial value (initial guess) that is used by the optimizer.

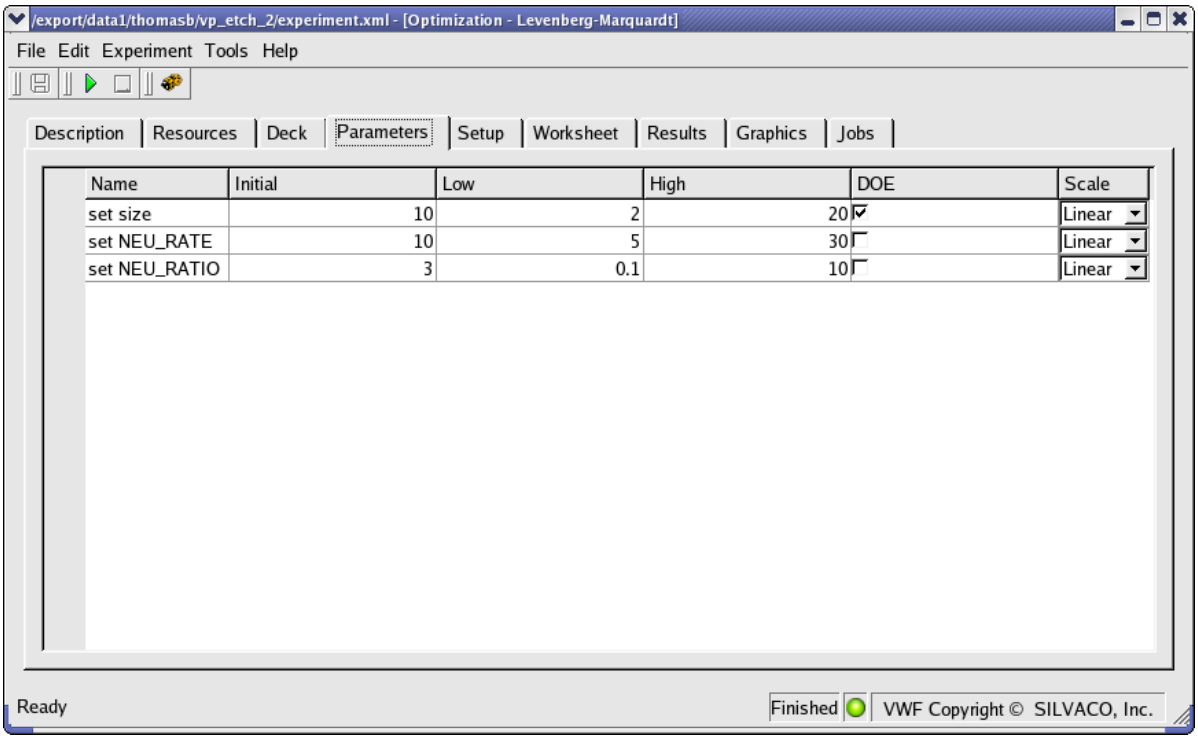

/export/data1/thomasb/vp_etch_2/experiment.xml - [Optimization - Levenberg-Marquardt]
File Edit Experiment Tools Help
Description Resources Deck Parameters Setup Worksheet Results Graphics Jobs
Name Initial Low High DOE Scale
set size 10 2 20 Linear
set NEU_RATE 10 5 30 Linear
set NEU_RATIO 3 0.1 10 Linear
Ready
Finished
VWF Copyright © SILVACO, Inc.

Figure 6-31 Optimizer and DOE Parameter Definition

Figure 6-32 depicts the setup pane, which is used to select a target for the optimization. In this example, the target is named `trenchdepth` and identifies the depth achieved by the etch process.

It is impossible to enter target values in the setup pane. This is in contrast to the simple type of optimization experiments, which do not use any DOE parameters. When a single DOE parameter is defined, target values for the selected target must be entered in the worksheet pane instead.

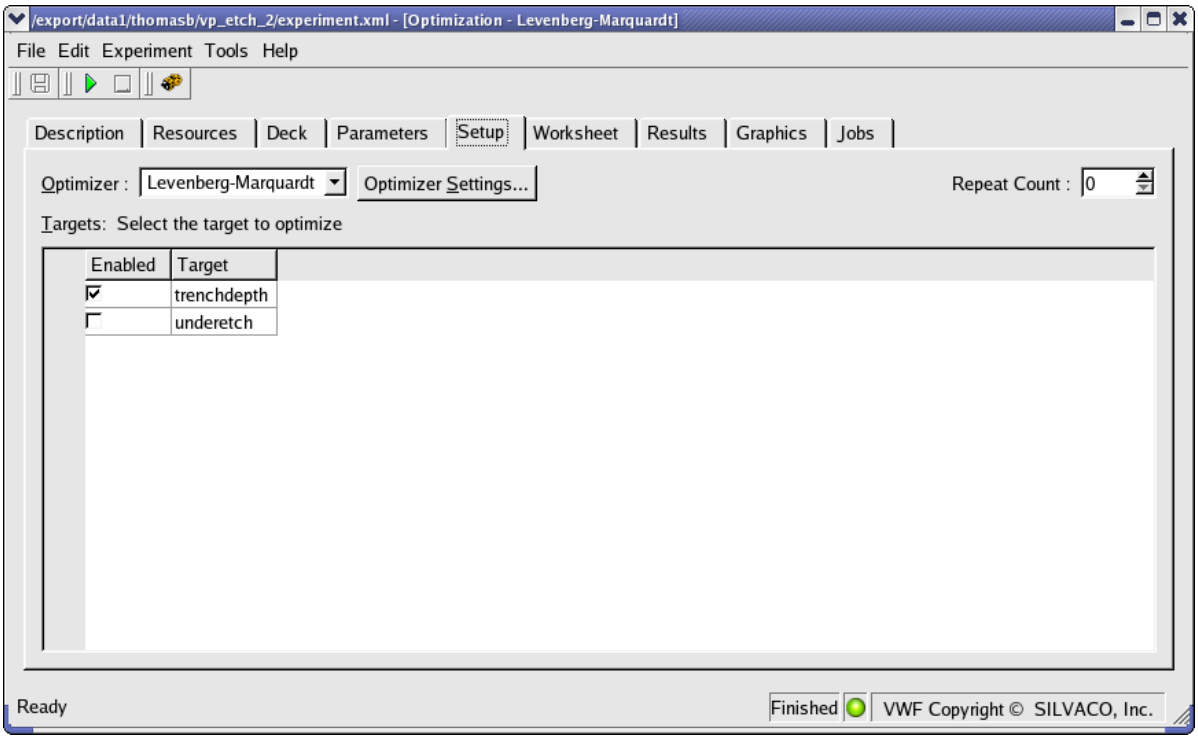


Figure 6-32 Definition of Optimizer Target

Figure 6-33 depicts the worksheet pane. It consists of three horizontally separated areas. The top most area shows the entered target values. Here, five target values corresponding to the five measured trench depths as given in Table 6-1 were entered.

The middle part of the worksheet pane shows the target script. This script is executed after all simulations for all combinations of target values were run. The supported script language is JavaScript. When the script is run, there are several pre-defined variables that can be accessed.

- `response` is an array that contains the simulated target values.
- `target` is an array that contains the target values entered at the top of the worksheet pane.

The order of how the array is populated follows the order of how target values were entered into the worksheet. The first value (here `51000`) is stored in `target[0]`, the second value (`70000`) is stored in `target[1]`, and so forth up to `target[4]` as the last entry, which contains a value of `87000`. The same ordering is also applied for responses, so that the value stored in `response[0]` corresponds to the simulation result for a mask width of `2`.

During execution, the target script must define a variable called `result`. This variable is given back to the optimizer (“return targets” in Figure 6-1). In this example `result` is an array with a length equal to that of `target`. This is suitable for the used Levenberg-Marquardt optimizer. Other optimizers, like, for example, the genetic optimization algorithm will require a scalar result value instead.

You can decide to optionally define a scalar variable called `cost`. This variable will characterize the quality of one iteration step in terms of deviation of measurement from simulation. If the `cost` variable is not defined in the script a default implementation is used, which computes a root mean square over all deviations for all entered target values.

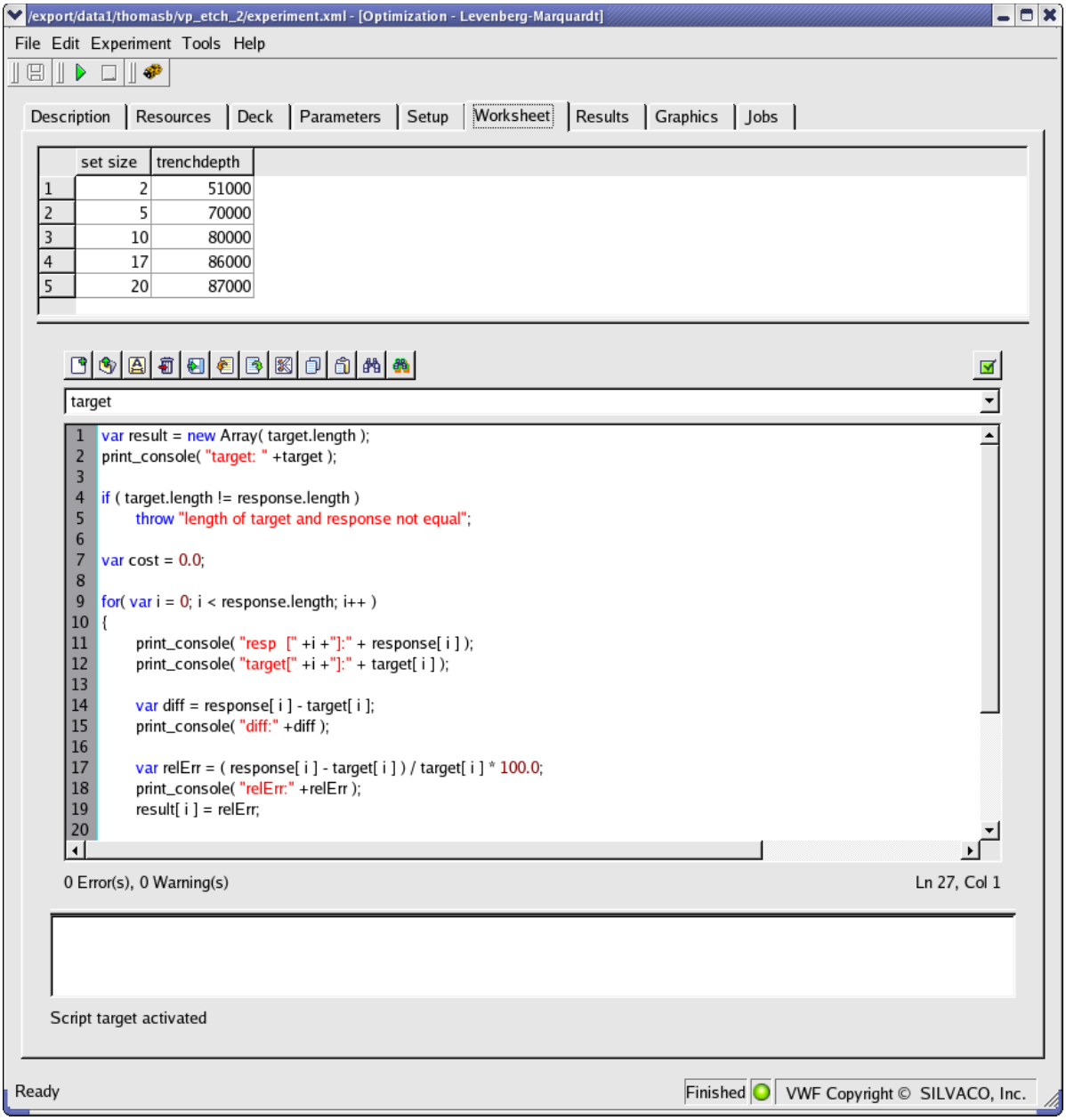

/export/data1/thomasb/vp_etch_2/experiment.xml - [Optimization - Levenberg-Marquardt]
File Edit Experiment Tools Help
Description Resources Deck Parameters Setup Worksheet Results Graphics Jobs
set size trenchdepth
1 2 51000
2 5 70000
3 10 80000
4 17 86000
5 20 87000
target
var result = new Array(target.length);
print_console("target: " +target);
if (target.length != response.length)
throw "length of target and response not equal";
var cost = 0.0;
for(var i = 0; i < response.length; i++)
{
print_console("resp [" +i +"]:" + response[i]);
print_console("target[" +i +"]:" + target[i]);
var diff = response[i] - target[i];
print_console("diff:" +diff);
var relErr = (response[i] - target[i]) / target[i] * 100.0;
print_console("relErr:" +relErr);
result[i] = relErr;
0 Error(s), 0 Warning(s)
Ln 27, Col 1
Script target activated
Ready
Finished
VWF Copyright © SILVACO, Inc.

Figure 6-33 Target Values and Target Script

Figure 6-34 shows the results pane. You can see that the best parameter combination found by the optimizer was `12,87` for `NEU_RATE` and `1.85` for `NEU_RATIO`. The obtained cost value for this combination is `0.0235` (`2.35%`). The obtained simulated trench depths are shown in Table 6-2.

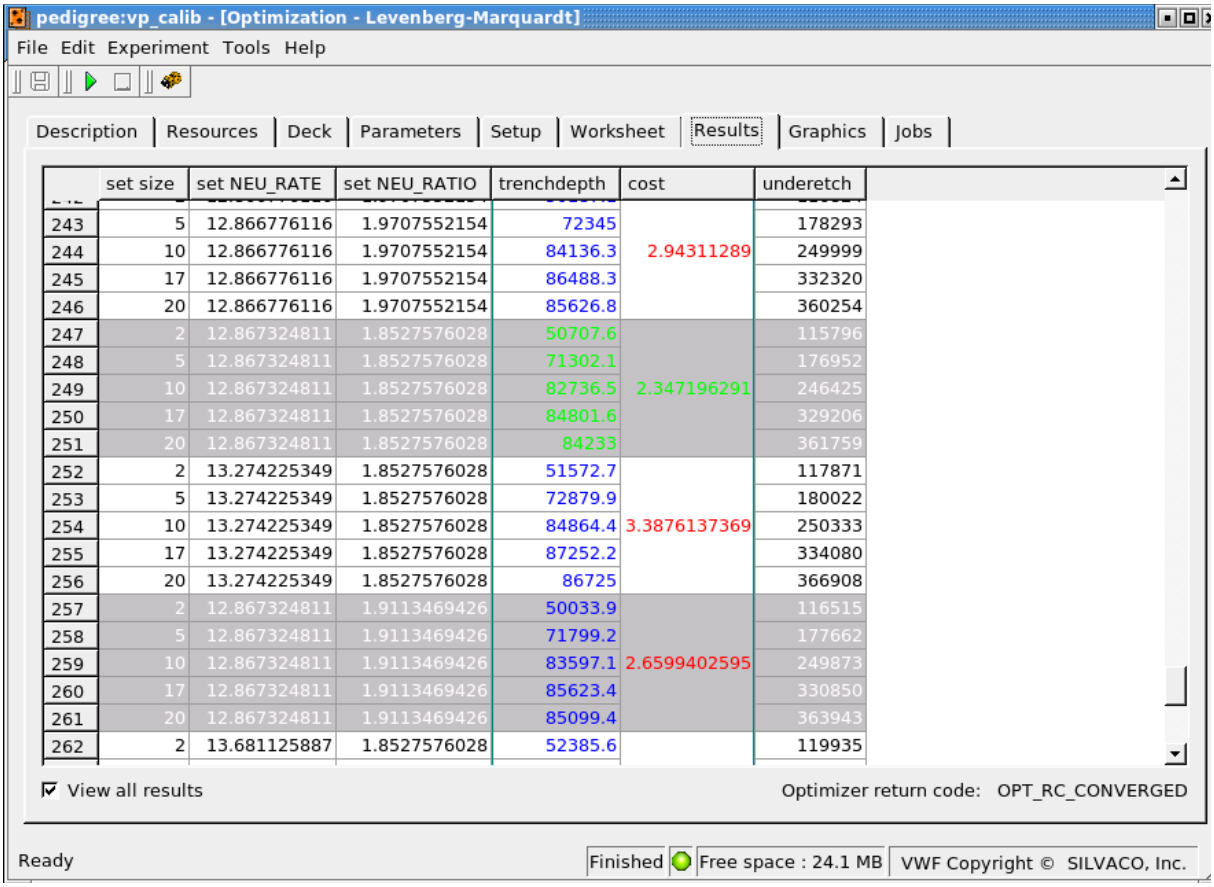


Figure 6-34 Calibration Results

Table 6-2 Simulated Trench Depths

Width [um]	Trench depth [angstrom]
2	50707.6
5	71302.1
10	82736.5
17	84801.6
20	84233

Figure 6-35 depicts how the optimizer progresses over time. You can see that the deviation measured as `cost` decreases with increasing iteration numbers. This shows the optimization problem achieves good convergence.

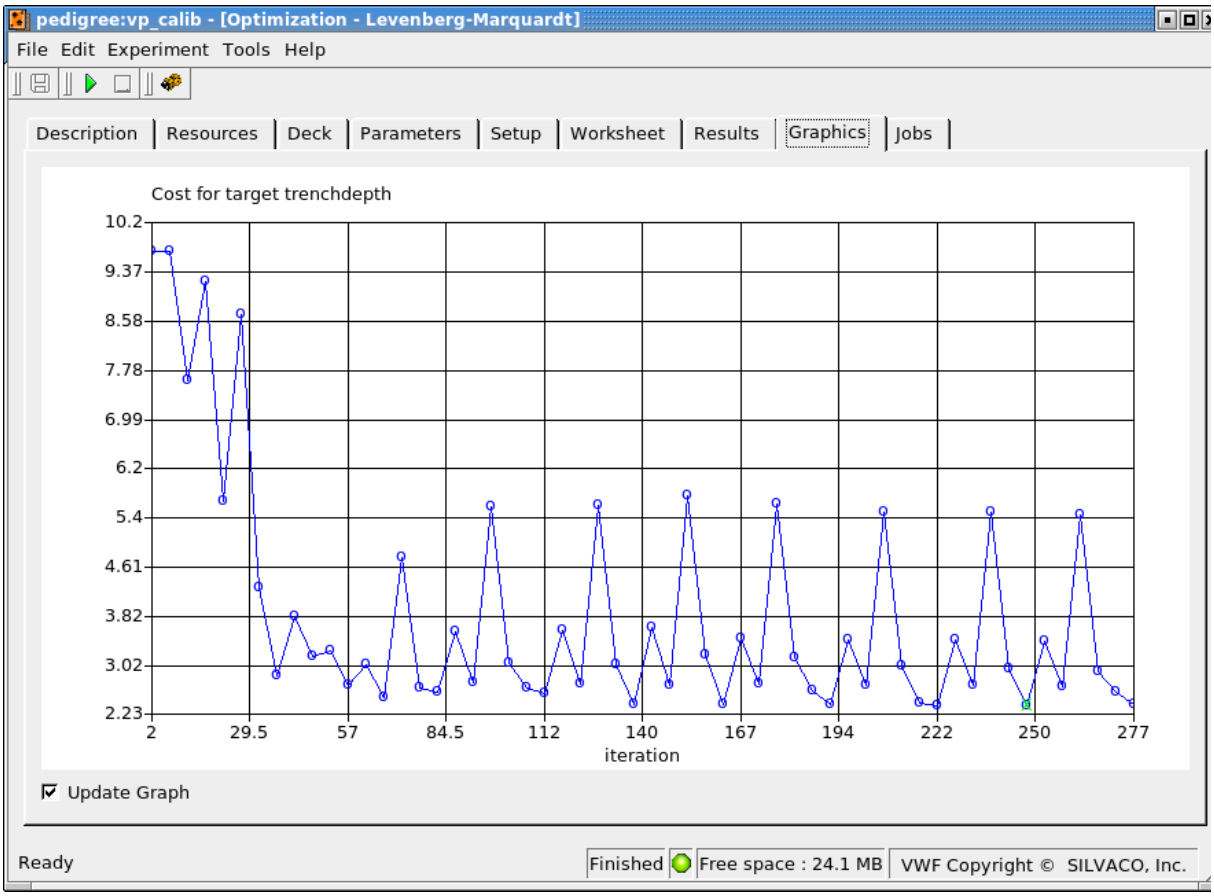


Figure 6-35 Progress of Optimization

6.8 References

1. Hauguth, M. “Integrated plasma processing simulation framework, linking tool scale plasma models with 2D feature scale etch simulator”, *Journal Microelectronic Engineering archive*, Volume 86 Issue 4-6, Elsevier Science Ltd. Oxford, UK, April, 2009

Chapter 7
Scripting in VWF

VWF offers a facility to carry out tasks in customer definable scripts. The scripting facility can be used to achieve the following tasks:

- Run experiments outside the GUI
- Define custom DOE strategies
- Define target scripts for the optimizer

Various examples for JavaScript scripts are given below. The JavaScript engine used in VWF is SpiderMonkey 1.7. A comprehensive documentation of the JavaScript engine and the JavaScript language can be found at

```
https://developer.mozilla.org/en-US/docs/SpiderMonkey
```

7.1 Run Experiments Outside the GUI

This mode is started by supplying the option `-js` when vwf is started. This option will avoid starting the GUI but will directly start executing the script, which is given after the `-js` option. When no script is given a short help is displayed:

```
thomasb@lannach$ vwf -js

a script to execute must be given with -js
```

As with the VWF GUI, you can opt to either run an experiment in filemode or in database mode. You will need to provide different information depending on what mode you run an example in. For instance in filemode, you need to provide the XML file, which contains the experiment. In database mode, you need to provide the `hostname`, where the database runs as well as the full login credentials and the experiment id. Below, two examples are given one for running a filemode example and one for running a database example. Finally, a script is shown, which allows to sequentially run several experiments.

7.1.1 Running a Filemode Experiment in Batch Mode

To run a filemode experiment in batch mode, you will first need to create an experiment using the GUI. You can do so by running the GUI in filemode and then start with a pre-defined example or create a new one from scratch.

After the experiment was created please exit the GUI and open a command window (shell). Below, the output of an example JavaScript script called `run_exp_filemode.js` is shown:

```
thomasb@lannach$ vwf -js ./run_exp_filemode.js

exec        /site/alpha/lib/vwf_js/2.10.5.R/x86_64-linux/vwf_js.exe
./run_exp_filemode.js

ID:1,type:jobQueued,message:

ID:2,type:jobQueued,message:

ID:3,type:jobQueued,message:

ID:1,type:experimentStarted,message:

ID:1,type:jobRunning,message:

ID:2,type:jobRunning,message:
```

The output indicates that the experiment was successfully opened and started, that some jobs have been queued, and that others are already running. As the experiment progresses, jobs will finish and others will be started until all jobs of the experiment have finally completed. The console output will indicate the progress as follows:

```
ID:2,type:jobFinished,message:

ID:3,type:jobRunning,message:

ID:1,type:jobFinished,message:

ID:3,type:jobFinished,message:

status:finished

finished, ID:1,type:experimentFinished,message:
```

Below, the example script `run_exp_filemode.js` is shown. If you want to run this script, you have to change the filename in the `XmlExperimentManager` object to contain the filename of the XML file you want to run. The script demonstrates how job status changes are obtained and displayed using the `print_console()` method and how the termination is handled when Ctrl-C is hit. The method "`stopExperiment`" is called to remove all pending jobs from the queuing system.

```
/* The following script demonstrates how a VWF experiment can be
run. */
var myMgr = new XmlExperimentManager( "vwfex01/experiment.xml" );

// clean all results in experiment
myMgr.cleanExperimentResults( );

// use the local queue
var myGrid = new Drmaa( "local" );

var myApp = new ApplicationCallback( myMgr );
var myExp = new RunExperiment( myMgr, myGrid, myApp, "" );

// start experiment
myExp.startExperiment( );

// callbacks are delivered via an event object
var     event = new Object( );
var status;
do
{
  status = myApp.waitForEventCheckFinished( event );
  if( status != 'terminate' )
    print_console( "ID:" +event.id +",type:" +event.type
                         +',message:' +event.msg );
} while( status != 'finished' && status != 'terminate' );

print_console( 'status:' + status );

if( status == 'finished' )
{
  status = myApp.waitForEventCheckFinished( event );
```

```
  print_console( "finished, ID:" +event.id +",type:" +event.type
                                  +',message:' +event.msg );
}
else if( status == 'terminate' )
{
  print_console( 'experiment was terminated by Ctrl-C' );
  myExp.stopExperiment( ); // stop experiment to remove
                           // all jobs from the queue
}

// END
```

7.1.2 Running a Database Experiment in Batch Mode

Running an experiment in database mode requires you to create an experiment in a database. You must do so using the GUI. You can either use an existing example shipped with VWF or you can define a new experiment . Once the experiment is created, do not run it but exit from the GUI and open a command window (shell).

The JavaScript script to run a database experiment in batch mode is not much different from the one to run a filemode experiment. The only difference is that instead of the `XmlExperimentManager` object you now need to use an object of type DatabaseExperimentManager. Below the line of code, which you need to replace is shown. Instead of:

```
var myMgr = new XmlExperimentManager( "vwfex01/experiment.xml" );
```

you now need to write:

```
var myMgr = new DatabaseExperimentManager( "lannach"    // hostname
            , "vwf_v5_up"  // database name
            , "demo"       // user name
            , "demo"       // password
            , 10012 );     // experiment id
```

The remainder of the script is identical to the script to run the filemode experiment.

The information you have to supply to the `DatabaseExperimentManager` object is as indicated in the comment above. To get the experiment id, you have to use the GUI and open the experiment. The id is part of the base directory of an experiment and can be obtained as shown in Figure 7-1. The last part of the base directory contains the id. In the shown screen shot, the id is 10012.

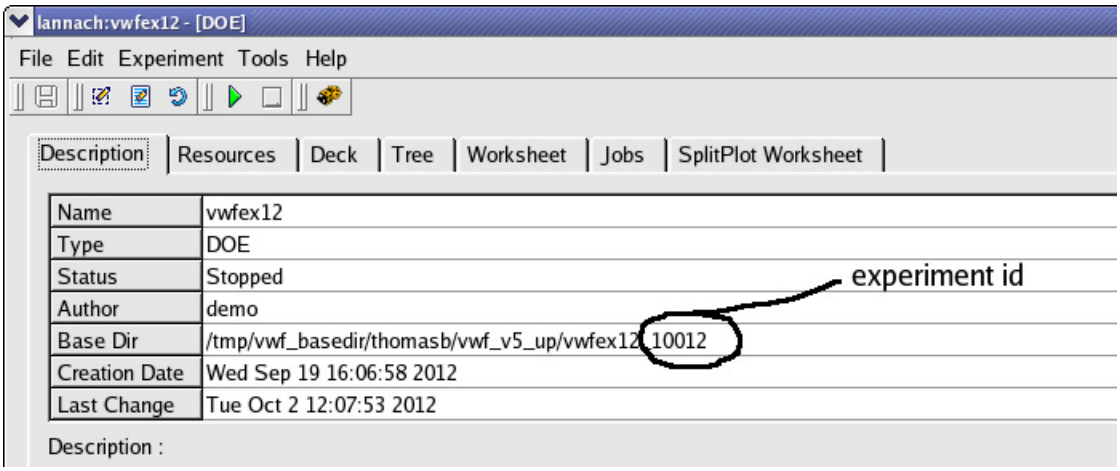


Figure 7-1 Obtaining the Experiment id for an Experiment

7.1.3 Running Several Experiments Sequentially in Batch Mode

In the JavaScript mode of VWF, you can essentially run any valid JavaScript code. Particularly, it is worth mentioning that you are not limited to running a single experiment at a time. Instead, you can setup a list of experiments, which are executed one at a time. Below, an example script is given, which executes experiments with ids `10001`, `10002`, and `10004` one at a time in the order of appearance:

```
/* The following script demonstrates how several VWF experiments can be
run.  */


// use the local queue
var myGrid = new Drmaa( "local" );


var experiments = [ 10001, 10002, 10004 ];


for( var i = 0; i < experiments.length; ++i )
{
  print_console( 'Running experiment:' +experiments[ i ].exp );


  var myMgr = new DatabaseExperimentManager( "lannach"    // hostname
                                      , "vwf_v5_up"       // database name
                                      , "demo"            // user name
                                      , "demo"            // password
                                      , experiments[ i ] ); // experiment id


  myMgr.cleanExperimentResults( );


  var myApp = new ApplicationCallback( myMgr );
```

```
  var myExp = new RunExperiment( myMgr, myGrid, myApp, "" );

  // start experiment
  myExp.startExperiment( );

  // callbacks are delivered via an event object
  var     event = new Object( );
  var status;
  do
  {
    status = myApp.waitForEventCheckFinished( event );
    if( status != 'terminate' )
      print_console( "ID:" +event.id +",type:" +event.type +',message:'
                           +event.msg );
  } while( status != 'finished' && status != 'terminate' );

  if( status == 'finished' )
  {
    status = myApp.waitForEventCheckFinished( event );
    print_console( "finished, ID:" +event.id +",type:"
     +event.type +',message:' +event.msg );
  }
  else if( status == 'terminate' )
  {
    print_console( 'experiment was terminated by Ctrl-C' );
    myExp.stopExperiment( );    // stop experiment to remove all jobs from
                                   the queue
    break;                      // Ctrl-C -> do not run other experiments
  }
}

// END
```

7.1.4 Using a Grid Environment in Batch Mode

You can also opt to use a grid computing environment like grid-engine or LSF when experiments are run in batch mode. This is independent from whether this is a filemode or database mode experiment. The example JavaScript scripts shown above contain a line of code to use the local queueing system:

```
var myGrid = new Drmaa( "local" );
```

In order to use a grid environment, you need to change that line to read:

```
var myGrid = new Drmaa( "sge" );
```

The jobs will then be queued into the queuing system when the script is executed.

7.1.5 Passing Options to the Queuing System

You may need to pass options down to the underlying queuing system. For instance, with grid-engine you need to add the options `"-shell yes"`. The way options are passed on to the queuing system is by means of an argument to the `RunExperiment` object. Below, the line of code to achieve this:

```
var myExp = new RunExperiment( myMgr, myGrid, myApp, "-shell yes"  );
```

To pass options down to the local queue, you have to use the `setSessionArgs` method.. Currently, options `maxJobs` and `maxLoad` are supported for the local queuing system. Essentially, the supported options are the same as what you can also change in the grid preferences pane of the VWF GUI. Below is an example on how to set options `maxJobs` and `maxLoad` of the local queuing system to 3 and 4 respectively:

```
var opts =  [ [ "maxJobs", "4" ]
            , [ "maxLoad", "3" ]
            ];
var myGrid = new Drmaa( "local" );
myGrid.setSessionArgs( opts );
```

7.1.6 Example JavaScript Files

Example scripts have been shipped with this version of VWF. You will find them in the installation directory of VWF. They are installed in `vwf/<version>/x86_64-linux/js/`. The following scripts are shipped:

```
run_experiment.js
run_several_experiments.js
FF2L.js
lhd.js
```

The scripts called `run_experiment.js` and `run_several_experiments.js` are copies of the examples described above. The scripts `FF2L.js` and `lhd.js` are examples for defining custom DOEs as described in Section 7.2 “Defining Custom DOE Strategies”.

7.2 Defining Custom DOE Strategies

This feature allows you to extend the built-in DOE design strategies by allowing to run a custom script to compute the sampling strategy. A new design dialog is available to select which parameters are to be used in the DOE as well as the script to run. Figures 3-54 and 3-55 depict the new dialogs.

To run the script, press after the script was loaded. VWF provides an example DOE strategy implementing an Orthogonal Maximin Latin-Hypercube Design. The script is a JavaScript implementation of the algorithm described in:

```
Orthogonal-Maximin Latin Hypercube Designs

V. Roshan Joseph and Ying Hung

School of Industrial and Systems Engineering

Georgia Institute of Technology

Atlanta, GA 30332-0205, USA

roshan@isye.gatech.edu and yhung@isye.gatech.edu
```

In the following, methods that are of specific interest for running a DOE script from within VWF are described in more detail. When the script starts, it needs to determine which parameters have been selected in the Custom Design dialog and what the parameter boundaries are for those parameters. The following code snippet retrieves the number of parameters and sets the number of points that will be computed. The object `"DesignDialog"` is an object, which is defined solely in the VWF GUI.

It is worth mentioning that this object is neither available when scripts are run using the `-js` option (as described in Section 7.1 “Run Experiments Outside the GUI”), nor when run from a JavaScript debugger or any other JavaScript engine.

```
function run( intervals )
{
  var axes_count = DesignDialog.getSelectedVarsCount( );


        // Compute points count
        var points_count = intervals;


        // Important : Set DOE points count in the dialog
        DesignDialog.setDOEPointsCount( points_count );
.
.
.
```

The part below demonstrates how the boundaries can be obtained for every selected parameter.

```
for( var i = 0; i < axes_count; ++i )
{
var d_min = DesignDialog.getMinValue( i );
var d_max = DesignDialog.getMaxValue( i );
```

.
.
.

After the computation is finished, the computed parameter values need to be transferred into the GUI.

```
for( var i = 0; i < axes_count; ++i )
{
for( var j = 0; j < intervals; ++j )
{
    var doeVal = val + ( xbest[ i ][ j ] -1 ) * incr;
    DesignDialog.setDOEValue( j, i, doeVal );
}
}
```

.
.
.

7.2.1 Running the Script

You can run a previously loaded script directly by clicking in the Script pane. This will automatically compile the script for you and run it immediately thereafter.

7.2.2 Compiling the Script

If you want to compile the script independently from running it (e.g., when you are debugging a syntax error), you can use the **Check Code** functionality. To invoke this, either press in the Script pane or press Ctrl-K.

Note: Some of the errors are undetectable this way and will only appear once the script is run.

7.2.3 Stopping a Running Script

Sometimes your script can be caught in an endless loop or can take unexpectedly long to complete. If this occurs, you can interrupt a running script. To do this, press in the Custom Design dialog.

7.2.4 Loading a Shared Library

Depending on what kind of script is being executed, it may be necessary to use some functions from the C-library and math-library of the system. This will be the case if you're writing any kind of numerical algorithm to compute your DOE strategy. In the Latin-Hypercube example provided, there are three functions used from the math-library. These are `srand`, `rand`, and `abs`.

Since these functions are not available in the JavaScript Math object, they must be provided in other ways. One way of achieving this is to implement these methods directly in JavaScript. A more convenient (and more performant) method of achieving this is to use the underlying math-library. In order to allow defining arbitrary C-functions usable from JavaScript, a shared library can be loaded prior to executing a script. The library must define a function `vwf_js_setup` with C-linkage and the following signature, which is defined in the provided header file called `vwf_js_setup.h`.

```
#ifndef VWF_JS_SETUP_H_INCLUDED
#define VWF_JS_SETUP_H_INCLUDED


#include <jsapi.h>


#ifdef __cplusplus
extern "C" {
#endif


          typedef int (*vwf_js_setup_t)( JSContext* ctx, JSObject*
global );


#ifdef __cplusplus
}
#endif


#endif  // VWF_JS_SETUP_H_INCLUDED
```

The implementation used for the Latin-Hypercube example is provided as C file `vwf_js_setup.c`. An example Makefile is also provided for you to compile the `.c` into a shared library `.so` file.

Once the file is compiled, it can be selected from the Custom Design dialog's script pane. The dialog shown in Figure 7-2 will open allowing you to select a shared object file.

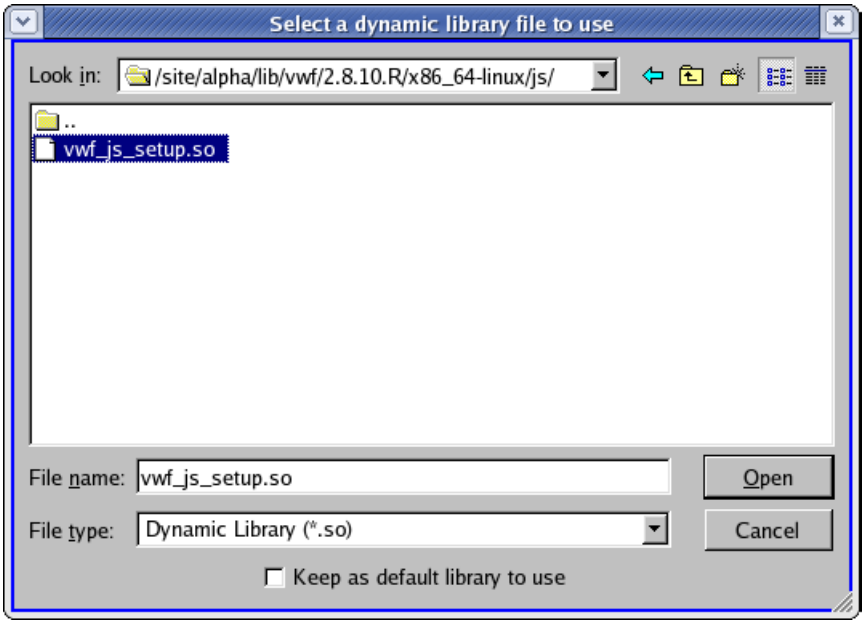


Figure 7-2 Choosing a Shared Library

If the library was not loaded, then an error will be displayed when the script is executed. Below is the error shown for the Latin-Hypercube example:

```
330: ReferenceError: srand is not defined
Execution failed: 1 error(s), 0 warning(s)
```

This indicates that a function `srand` is needed from the script but is unavailable.

7.2.5 Writing Messages to the Console

The VWF system defines a method where you can write messages directly into the console of VWF. This can be done using the `print_console` function. The following code snippet demonstrates this:

```
print_console( " dbar: " +dbar );
print_console( "    c: " +c );
print_console( "   p0: " +p0 );
```

Above statements will print the values of variables `dbar`, `c`, and `p0` to the console.

7.3 Defining Target Scripts for Optimization

This allows you to override the default way of how VWF computes the optimization target out of simulation results. Please refer to Section 6.7 “Optimization Example: Advanced Calibration Task”.

Chapter 8
Security Concepts in VWF

This version of VWF implements a tight security module. This module is optional and is only active in database mode. Please refer to Section 2.3.2 “Database Mode” for a description of how to install the system.

8.1 Introduction

The basic concept of the security module follows the scheme of users and groups. For both users and groups, access rights can be defined on every entity within the VWF system. An entity is either a directory, an experiment or a file in the VWF system. Methods exist to propagate permissions from a parenting directory to all its children recursively to allow for quickly adding new users/groups.

When you create a new database, a superuser called `admin` is created. The initial password for this user is set to `admin`. You can change the password of the superuser (and that of any other database user), using the SRDB utility. Below, an example is given to change the password of the `admin` user from the initial `admin` to the string `mypasswd`.

```
SRDB >login lannach simucad

SRDB lannach >list

Logged onto server lannach

<Available databases>

baseline_2012                VWF     V6    /build/silvaco/var/srdb/
baseline_2012.fdb

SRDB lannach >

SRDB lannach >connect baseline_2012

SRDB lannach [baseline_2012] >list users


USERS

-----

User : admin      Status : NORMAL     Groups :

User : demo       Status : NORMAL     Groups :

User : demo2      Status : NORMAL     Groups :

User : superuser  Status : SUPERUSER  Groups :


SRDB lannach [baseline_2012] >

SRDB lannach [baseline_2012] >

SRDB lannach [baseline_2012] >password admin mypassword

User admin password modified successfully.

SRDB lannach [baseline_2012] >
```

Compared to the local execution mode (no `vwf_daemon` used) or the filemode (no database used), this mode of operation poses some restrictions as to how and where experiments are executing. Here, a separate server process will be used to execute your experiments. For every experiment that you open in the GUI, a separate server process will be started. Once you press the **Run** button in the experiment window, you can close the GUI. The server process will take care to farm out your jobs to the underlying grid and will collect all job status information and experiment results. Later, when you restart the VWF GUI, you can obtain the results by re-opening the previously started experiment. You will instantly notice whether the experiment is still be running at this time by looking at the status. If the experiment is running, live job status updates will be shown in the same way as you know from local database mode and filemode.

To tightly secure the system, the server processes are run under a certain UNIX user-id (called `vwf_user`). The `vwf_user` will normally be different from your UNIX account and pemissions of the `vwf_user` will not normally allow you to directly access any data on the harddisk. Instead, the VWF GUI decides which VWF user can access what data.

8.2 Security Related Dialogs

In the following, all security related dialogs and menu entries are shown. Examples of how a particular security setting will look in the browser window will be shown.

Figure 8-1 displays the menu entry, which will open the Superusers dialog shown in Figure 8-2. The Superusers dialog allows you to nominate/denominate any of the database users as a superuser. The check box at the right-hand side of the dialog displays, which users are superusers. Only a superuser is allowed to change this flag.

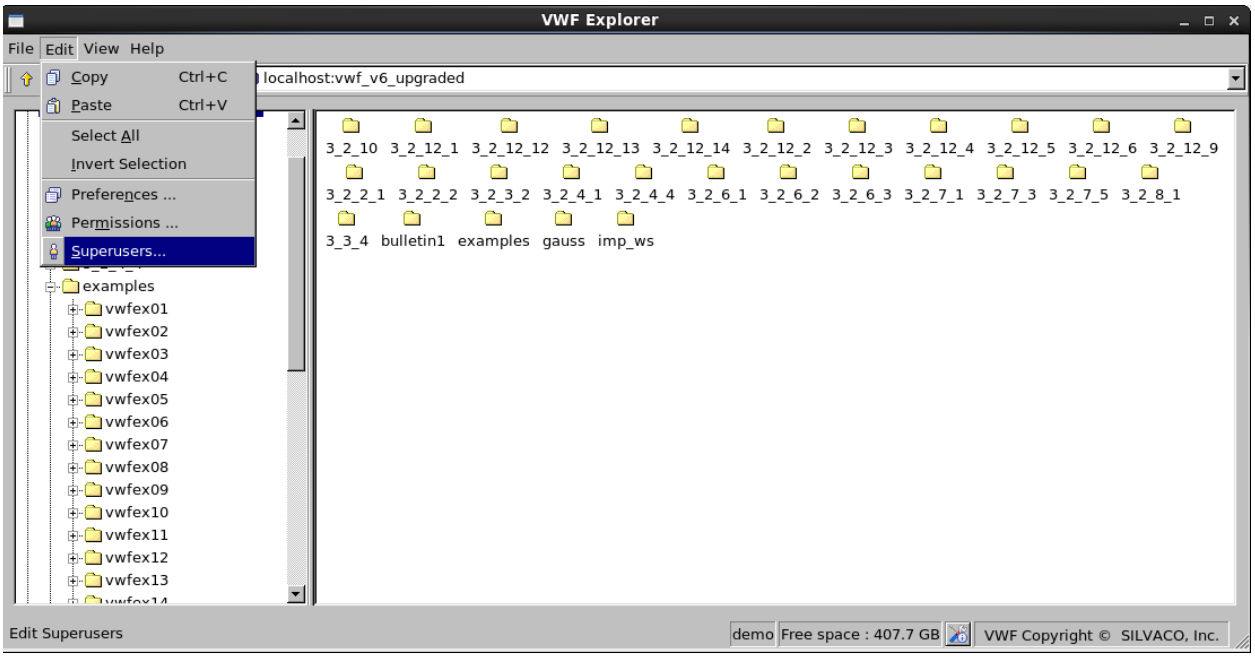


Figure 8-1 Edit Superusers Menu Entry

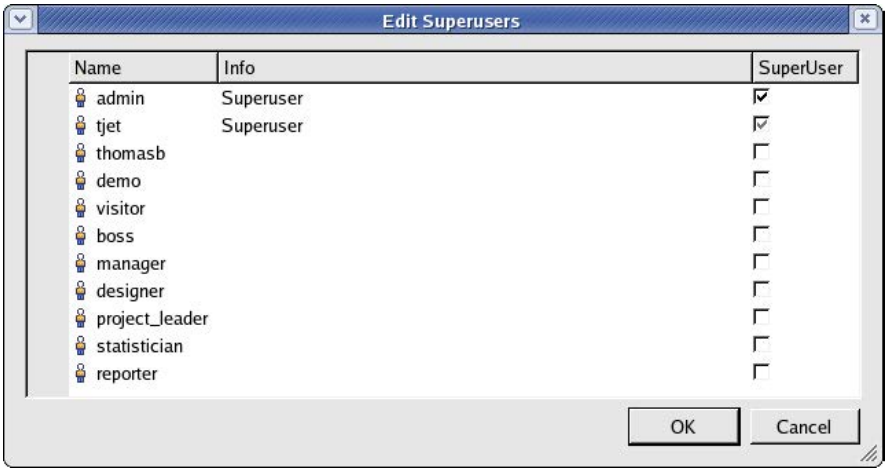


Figure 8-2 Edit Superusers Dialog

Figure 8-3 displays the menu, which opens when you right-click on a directory entry in the browser window. When you select the entry **Permissions**, the dialog shown in Figure 8-4 will open. This dialog allows to define the rights for every user in the system. The screen-shot shows 3 groups **Design**, **Analyze**, **Taskforce**, and several individual users. You can see that everybody in the system has got read permissions for that directory but only users `tjet` and `admin` have full rights.

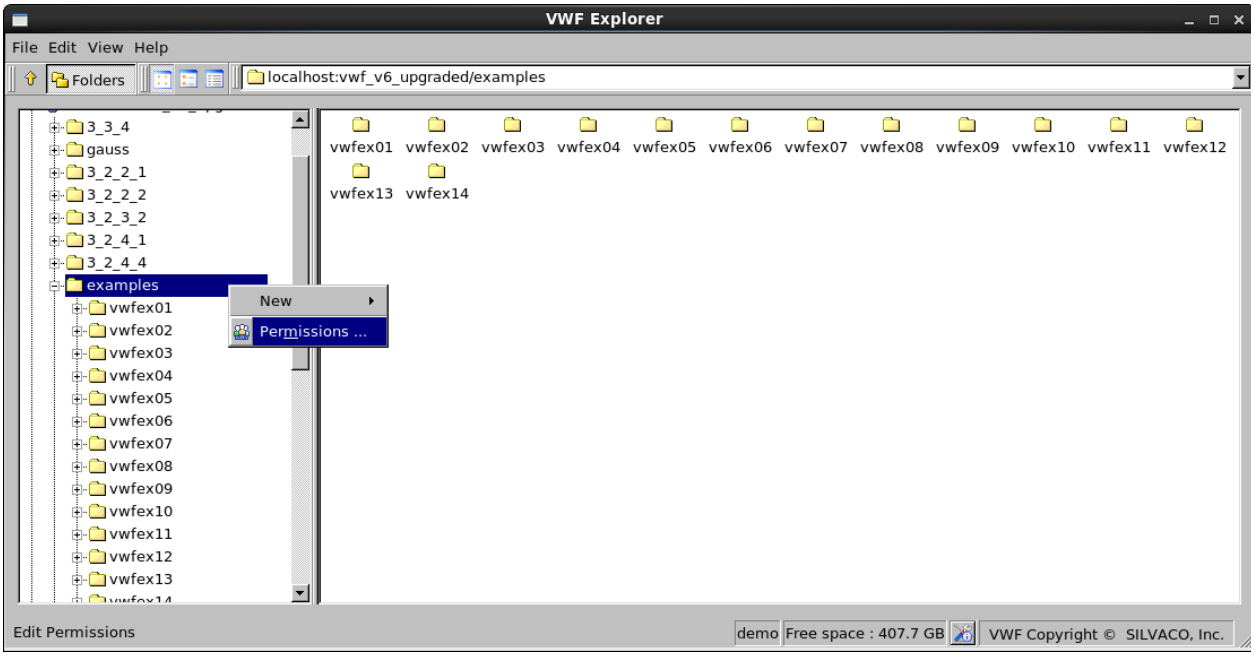


Figure 8-3 Permissions Context Menu Entry

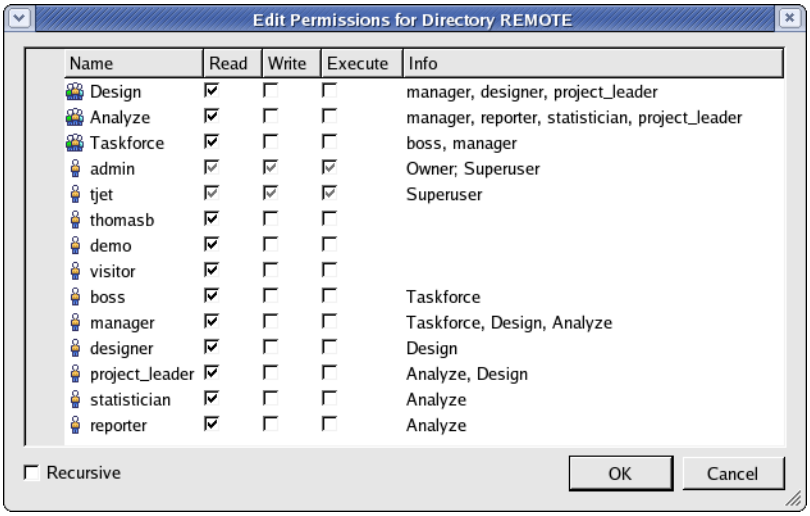


Figure 8-4 Permissions Dialog

Figure 8-5 presents the browser view with a couple of entries for the various users. The right-hand side depicts the ownership of the shown entities.

Figure 8-6 displays how the experiment window title changes to show that an experiment was opened read only.

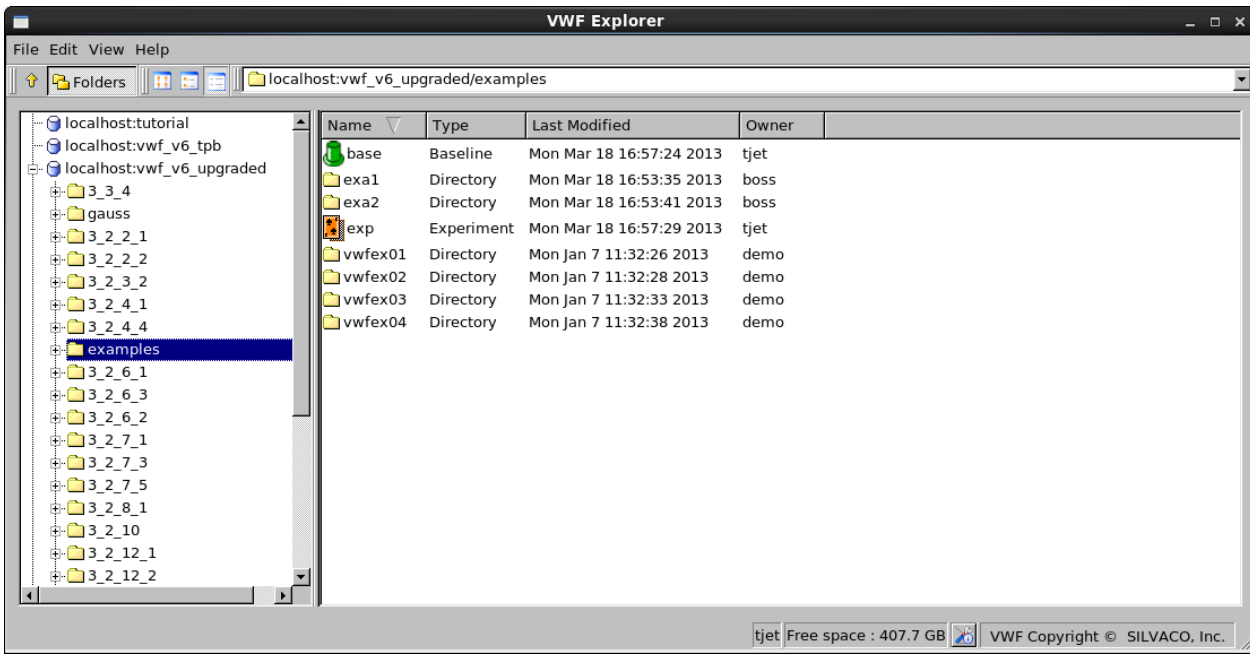


Figure 8-5 Security – Browser View with Several Users Shown

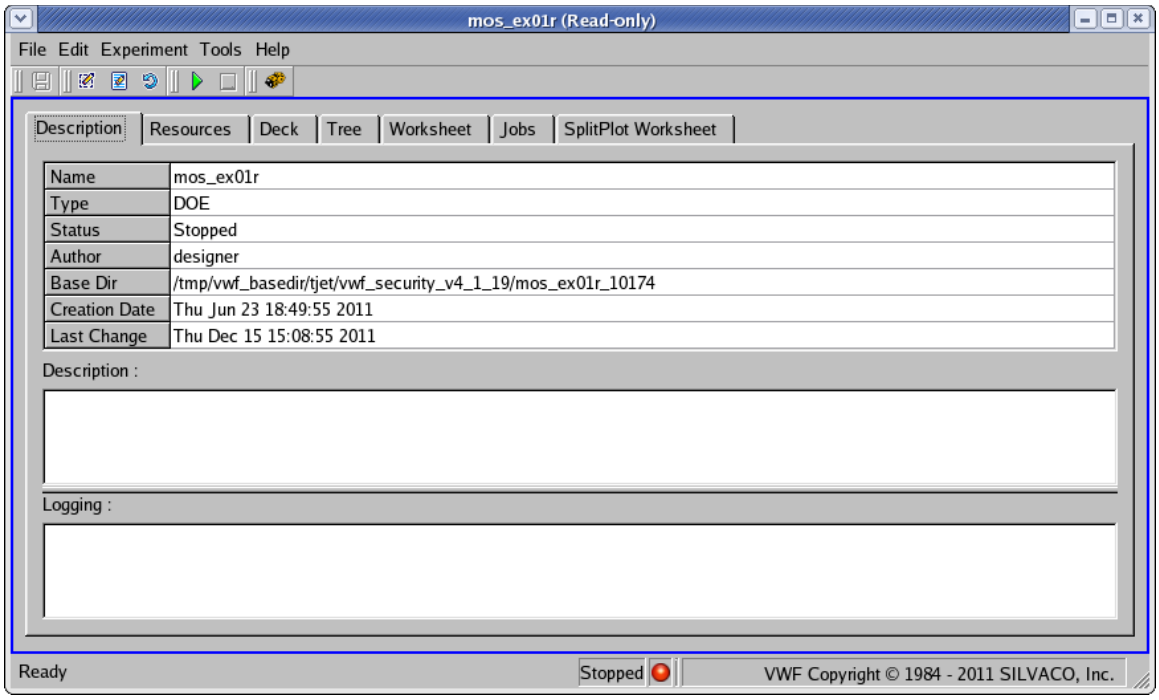


Figure 8-6 Security – Experiment Opened Read Only

Figure 8-7 depicts the case where an attempt was made to change an experiment, which is opened read only. The edit operation is canceled and a dialog will appear showing that you don't have enough privileges.

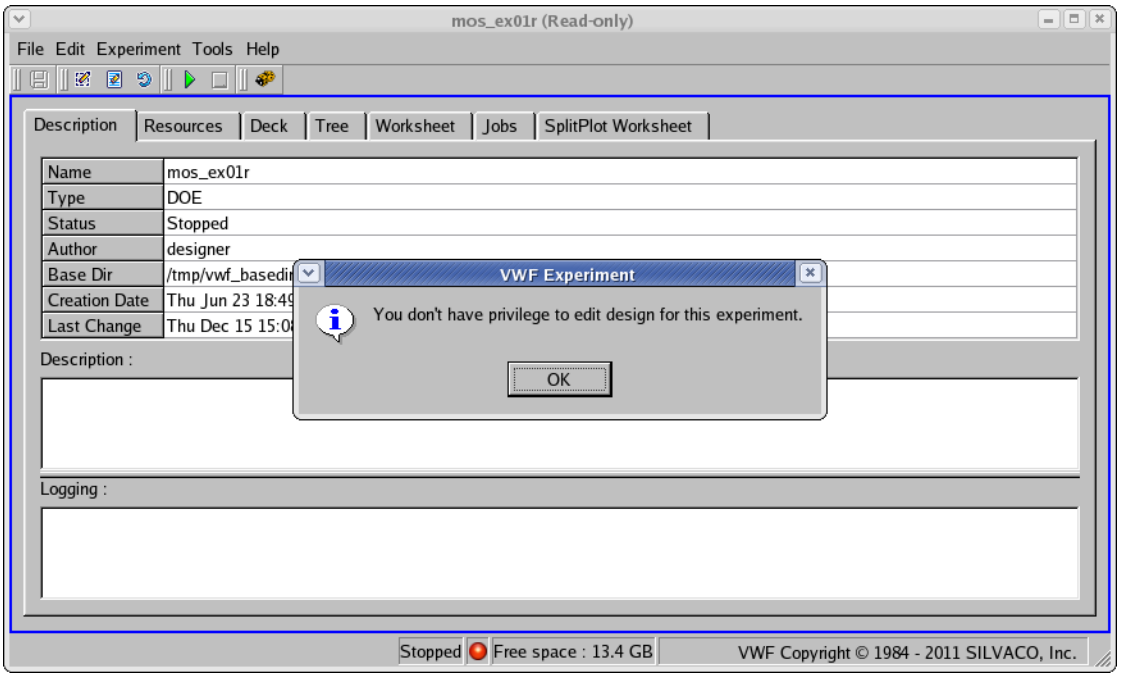


Figure 8-7 Security – Attempt to Open an Experiment without Privileges

Appendix A
Database Maintenance

A.1 Backing up VWF Data

It is advisable to periodically backup all data stored in VWF. This ensures you can safely restore your work after a computer or hard disk crash without having to re-enter all the data or re-run lengthy simulations.

Let us distinguish the types of data that are being dealt with in VWF. When you are using the database, then there are two basic modes of operation:

- One mode is the database local mode, where all the simulation files are kept locally in the `/tmp` folder of your workstation. This is the default mode of operation, which did not require you to run the `vwf -install` command when you installed VWF. Please proceed directly to Section A.4 “SRDB Utility”.
- The second mode of operation will store all simulation files on a central server. This mode required you to run the `vwf -install` command when you installed vwf. In this mode, two separate utilities (`vwf_backup` and `vwf_restore`) are provided to perform the task of backing up and restoring a VWF system. Backups can either be created manually or by using a UNIX system utility like `cron`.

Note: The utilities do not need to be run as root user.

Note: The utilities need to be run on the server, which also holds your simulation files.

Please refer to Chapter 2 “Installation” for a more detailed description of the VWF modes of operation.

A.2 vwf_backup

You can use this utility to create a single zipped TAR file of the contents of the VWF database and the VWF fileserver location. (The latter contains all the runtime output as it was generated during simulations.) The tool uses the underlying SRDB utility to create a database dump. It does not come with its own GUI. Instead, it is a command line utility. If invoked without an argument, it gives a brief usage message.

```
thomasb@lannach$ vwf_backup

                                    V W F _ B A C K U P

                                Copyright (C) 1984 - 2013

                              Silvaco Inc. All rights reserved


INFO  version info:vwf_backup 2.12.0.R (Thu Mar 14 15:32:53 CET 2013)

ERROR option -host missing

ERROR option -passwd missing

ERROR option -db missing

ERROR option -file missing


usage: vwf_backup -host hostname -db database-name -passwd password
      -file output file [-srdb path_to_srdb] [-flags flags_to_srdb]
                        [-properties properties-file]
                              [-bd base_directory]
        -srdb       ... select which srdb version to use (default uses srdb from
                        $SILVACO/bin)
        -flags      ... pass flags to srdb command (e.g. to select a particular
                        version)
        -properties ... take all options from a properties file (all other
                        options are ignored)


e.g. : vwf_backup -host lannach -db vwf_test -passwd simucad
                          -file backup_test_20081210.tgz


         This will attempt to make a backup of database vwf_test
         on server lannach and store the dump together with all
         result files in a file called backup_test_20081210.tgz.
         The password used for the connection is simucad.


or   : vwf_backup -srdb /build/silvaco/bin/srdb -flags "-V 10.0.11.R"
```

```
                                -host lannach -db vwf_test -passwd simucad
                                -file backup_test_20081210.tgz


            Same as above except that srdb is taken from /build/silvaco/bin
            rather than from $SILVACO/bin, and that version 10.0.11.R is executed
            instead of the default version.


    or    : vwf_backup -properties properties.config
            This will take all options from the properties file
        instead of the commandline
```

The first line of the output displays the version number of the utility. After that a list of missing mandatory arguments is given. The tool allows two ways of specifying the necessary arguments. One is to use the command line, the other is to store the info in a separate properties file. The following `vwf_backup` arguments are mandatory:

- `-host` identifies the host of where the database server is running.
- `-passwd` identifies the system password of the database to backup.
- `-db` identifies the database. This is necessary since there can be several databases hosted on a database server.
- `-file` is the output file, which contains the zipped and tared contents of database and fileserver.

`vwf_backup` supports the following optional arguments:

- `-srdb` to use a different utility than the default srdb utility found in `$SILVACO/bin`.
- `-flags` to pass command line options down to the srdb utility (e.g., to select a particular srdb version).
- `-properties` to specify a properties file, which contains all of the mandatory and any of the optional arguments.
- `-bd` to specify a base directory other than the one, which was configured at installation time.

Note: If you are running VWF in default mode (when you did not use `vwf -install`), then `vwf_backup` takes the simulation files from the default location (`$HOME/vwf/vwf_basedir`). This is also indicated by the output of `vwf_backup`.

The last line of the output of vwf_backup shown below indicates that you are running VWF in default mode.

```
thomasb@lannachn$ vwf_backup


                                V W F _ B A C K U P
                              Copyright (C) 1984 - 2013
                            Silvaco Inc. All rights reserved

INFO  version info:vwf_backup 2.12.1.R (Wed Apr  3 13:08:23 CEST
2013)
INFO  config file /build/silvaco/var/vwf_ii.cfg not existing, using
default locations for simulation files
```

A.2.1 Examples

The following shows a short list of examples on how to use the vwf_backup utility.

Manually create a backup

This example creates a backup of a database called vwf_demo2 on server lannachn and stores it in a TAR file called vwf_demo2_20130318.tgz. The runtime output below details the progress of the utility. You can see that the backed up base directory is /build/silvaco/var/vwf_base_local/vwf_demo2.

```
thomasb@lannachn$ vwf_backup  -host lannachn -passwd simucad -db vwf_demo2
-file vwf_demo2_20130318.tgz


                                V W F _ B A C K U P
                              Copyright (C) 1984 - 2013
                            Silvaco Inc. All rights reserved


INFO  version info:vwf_backup 2.12.0.R (Thu Mar 14 15:32:53 CET 2013)
INFO  Backing up simulation files from directory "/build/silvaco/var/
vwf_base_local/vwf_demo2" to file:vwf_demo2_20130318.tgz
```

Note the usage of the passwd option.

Create a backup in default mode

This example shows the slightly changed output of the vwf_backup utility when the VWF default mode is used. You can see that the simulation files are now taken from the default location.

Note: The vwf_backup utility honors the VWF_BASEDIR environment variable.

```
thomasb@lannachn$ vwf_backup -host lannachn -passwd simucad -db
vwf_v7_tpb -file tpb.tgz


                                V W F _ B A C K U P
                              Copyright (C) 1984 - 2013
                            Silvaco Inc. All rights reserved


INFO  version info:vwf_backup 2.12.1.R (Wed Apr  3 13:08:23 CEST
2013)
INFO  config file /build/silvaco/var/vwf_ii.cfg not existing, using
default locations for simulation files
INFO  Backing up database vwf_v7_tpb to file tpb.tgz
INFO  Backing up simulation files from directory "/export/data1/
thomasb/vwf/vwf_basedir/vwf_v7_tpb" to file:tpb.tgz
```

Use a properties file

Instead of passing arguments through a command line, they can be stored in a separate file. This can be useful to quickly backup several databases without having to worry about all the details each time, or to ease usage of automated backups (see example below). It also avoids the specified password being exposed to other users (command line arguments can be seen by every user in the system by means of the `ps` UNIX command). Each line in the file specifies exactly one argument.

```
host=lannachn
passwd=simucad
#srdb=/site/alpha/bin/srdb
db=vwf_demo2
file=vwf_demo2_20130318.tgz
```

Note: The `'#'` character at the beginning of a line introduces a commented (unused) line.

Below, shows the output of the backup utility for the contents of a properties file above. In this example, the properties file is called `bak.props`.

```
thomasb@lannachn$ vwf_backup -properties ./bak.props

                                V W F _ B A C K U P

                            Copyright (C) 1984 - 2013

                          Silvaco Inc. All rights reserved


INFO  version info:vwf_backup 2.12.0.R (Thu Mar 14 15:32:53 CET 2013)
INFO    Backing up simulation files from directory "/build/silvaco/var/
vwf_base_local/vwf_demo2" to file:vwf_demo2_20130318.tgz
```

Note: Other options can still be given together with -properties. Options specified explicitly will override any settings in the properties file.

Automated backup through UNIX cron

In a production environment, it is easy to automate the task of regularly backing up a database system. To do this, use the `vwf_backup` utility together with a properties file and the UNIX `cron` facility. For instance to make a regular backup every day at 3am, use a crontab entry similar to the following.

```
00 03 * * * /site/alpha/bin/vwf_backup -properties /build/thomasb/
vwf_training.config -file backup.tgz
```

The following example illustrates the usage of a small shell script to have date and time in the name of the created backup file.

```
#!/bin/sh

/site/alpha/bin/vwf_backup       -properties       /build/thomasb/
vwf_training.config
-file backup_`date +%Y%m%d_%H%M`.tgz
```

Please consult the manual pages of the `cron`, `bash`, `csh`, and `date` UNIX commands for full details.

A.3 vwf_restore

This tool performs the task of restoring a backup previously created with `vwf_backup` to a database server. It restores both the database dump and the simulation results. If invoked without any arguments, it prints a brief usage message.

```
thomasb@lannachn$ vwf_restore

                                V W F _ R E S T O R E

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file to restore from must be given


usage: vwf_restore -host hostname -passwd password filename
      [-dbdir directory ][-srdb srdb][-flags flags][-properties properties-file]
         -dbdir      ... select to which directory the database is restored to
         -basedir    ... select a different than the default base directory
         -dbname     ... select a different than the default name for the
                         database.
                             The name is relative to the base directory
         -srdb       ... select which srdb version to use (default uses srdb from
                         $SILVACO/bin)
         -flags      ... pass flags to srdb command (e.g. to select a particular
                         version)
         -properties ... take all options from a properties file (all other
                          options are ignored)


e.g. : vwf_restore -host lannach -passwd simucad backup_test_20081210.tgz


         This will attempt to restore a previously created backup
         from file backup_test_20081210.tgz on server lannach.
         All files are restored together with the database
         The password used for the connection is simucad.


or   : vwf_restore -host lannach -passwd simucad backup_test_20081210.tgz
                              -dbdir /build/silvaco/var/srdb
```

```
            Same as above except that the database is restored

            to directory /build/silvaco/var/srdb rather than the default.


    or   : vwf_restore -properties properties.config

            This will take all options from the properties file

        instead of the commandline
```

Options have the same meaning as in `vwf_backup` with the following exception:

- `-dbdir` allows you to specify the directory where the database dump is to be restored. This corresponds directly to the target directory of the SRDB utility (see below).
- `-basedir` allows you to select a different than the base directory as stored in the backup file.
- `-dbname` allows you to specify an alternative name for the database. This is useful if a database with the name stored in the backup file is already existing.

To restore a backup file, the base directory location of that database must be empty and the database must not be existing in firebird. Otherwise, an error message will be printed and no action will be taken.

```
thomasb@lannachn$ vwf_restore -host lannachn -passwd simucad ./
vwf_demo2_20130318.tgz

                                V W F _ R E S T O R E
                              Copyright (C) 1984 - 2013
                            Silvaco Inc. All rights reserved


vwf_restore::RestoreError, MSG:base directory /build/silvaco/var/
vwf_base_local/vwf_demo2 already existing, consider using the -dbname
option
```

Here's the output when everything was restored properly:

```
[root@lannachn thomasb]# vwf_restore -host lannachn -passwd simucad
./vwf_demo2_20130318.tgz

                                V W F _ R E S T O R E
                              Copyright (C) 1984 - 2013
                            Silvaco Inc. All rights reserved


LIBRARIES   /build/silvaco/lib/firebird/1.5.2.R/x86_64-linux/lib:/
build/silvaco/lib/firebird/1.5.2.R/x86_64-linux:/usr/lib:/lib:/
usr/openwin/lib:/build/silvaco/lib/support/x86_64-linux:/build/
silvaco/lib/support/i386-linux

Use CONNECT or CREATE DATABASE to specify a database
```

Below, shows the output when you are running VWF in default mode. You can see that the simulation files are restored to the default location.

```
thomasb@lannachn$ vwf_restore -host lannachn -passwd simucad -
dbname tpb1 tpb.tgz


                                V W F _ R E S T O R E

                              Copyright (C) 1984 - 2013

                            Silvaco Inc. All rights reserved


INFO  version info:vwf_restore 2.12.1.R (Wed Apr  3 13:08:25 CEST
2013)

INFO  config file /build/silvaco/var/vwf_ii.cfg not existing, using
default locations for simulation files

INFO  VWF DB version:7

INFO  Restoring simulation files to directory /export/data1/thom-
asb/vwf/vwf_basedir/tpb1

LIBRARIES   /build/silvaco/lib/firebird/1.5.2.R/x86_64-linux/lib:/
build/silvaco/lib/firebird/1.5.2.R/x86_64-linux:/build/grid/lsf/
7.0/linux2.6-glibc2.3-x86_64/lib:/usr/lib:/lib:/usr/openwin/lib:/
build/silvaco/lib/support/x86_64-linux:/build/silvaco/lib/support/
i386-linux

Use CONNECT or CREATE DATABASE to specify a database
```

A.4 SRDB Utility

The SRDB utility, which was used to create a VWF database, must also be used to carry out the administrative tasks explained below.

A.4.1 Making a Backup

While it is preferable to use the `vwf_backup` utility to backup your data, you can also do so by using the SRDB utility directly.

Note: When you are using the database remote mode, it is preferable to use the `vwf_backup` utility to backup your simulation files and database in one go.

Note: Only the database dump will be created. The simulation result files must be backed up separately as detailed below.

To create a backup start SRDB, connect to a database and use the following SRDB command:

```
lannach >list

Logged onto server lannach

<Available databases>

vwf     VWF

lannach >backup vwf vwf.bak.20080901

LIBRARIES    /build/silvaco/lib/firebird/1.5.2.R/x86_64-linux/lib:/
build/silvaco/lib    /firebird/1.5.2.R/x86_64-linux:/usr/lib:/lib:/
usr/openwin/lib:/build/silvaco/lib    /support/x86_64-linux:/build/
silvaco/lib/support/i386-linux

Database vwf backed up to /root/vwf.bak.20080901 on server lann-
ach.Silvaco.COM.

lannach >
```

The command above will create a backup file called `vwf.bak.20080901`, which contains the contents of the database `vwf`. Note the usage of the date in the filename `vwf.bak.20080901`.

Please note that the simulation result files must be backed up separately in this case. To do so, use the UNIX TAR command as follows:

```
tar   cvzf   /root/vwf_files.bak.20080901.tgz   /build/silvaco/var/
vwf_base
```

The above command will create a GNU-zipped TAR file containing all files and directories of the directory `/build/silvaco/var/vwf_base`. The given directory must be the base directory for your experiments.

Note: The TAR command must be run as `root`.

A.4.2 Restoring a Database from a Backup

To restore a previously backed up database, you need to have the backup file available. For the examples outlined above this is the file called `vwf.bak.20080901`. The database (`vwf`) must not be existing in the system where you want to restore or an error will be shown.

To restore the file, start SRDB, connect to a database, and use the following SRDB command:

```
lannach >list

Logged onto server lannach

<Available databases>

lannach >

lannach >restore /root/vwf.bak.20080901 VWF

Database restoration. Target directory not specified. Defaulting to /
build/silvaco/var/srdb/.


LIBRARIES     /build/silvaco/lib/firebird/1.5.2.R/x86_64-linux/lib:/build/
silvaco/lib/firebird/1.5.2.R/x86_64-linux:/usr/lib:/lib:/usr/openwin/lib:/
build/silvaco/lib/support/x86_64-linux:/build/silvaco/lib/support/
i386-linux

Database VWF restored as /build/silvaco/var/srdb/VWF.fdb on server
lannach.

lannach >list

Logged onto server lannach

<Available databases>

VWF     VWF
```

To restore the simulation result files, please change to your base directory and untar the TAR file created in the backup step (`vwf_files.bak.20080901.tgz`).

Note: You also need to restore the simulation result files in the very same location where you took them from when the TAR file was created. In the above example, this directory was called `/build/silvaco/var/vwf_base`. Use a command as follows to untar the result files:

```
cd /
tar xvzf /root/vwf_files.bak.20080901.tgz
```

Note: It is advisable to use dates in names for backup files. This ensures you can match a database export file with the corresponding TAR file containing the result files. Both the database file and the TAR file should be created at a time where the system is mostly idle (e.g., at night time) and at the same time. On UNIX systems, a cron job is best suited for that task.

Note: The TAR command must be run as `root`.

Appendix B
Queuing VWF On The Oracle/SUN Grid Engine/ Open Grid Scheduler

B.1 Installing the Open Grid Scheduler

Please note that the grid computing software Sun Grid Engine is no longer maintained as an open source package as of 12-31-10. Future updates as well as commercial support for the fully compatible Oracle Grid Engine package is available from Oracle. Please refer to Section B.7 “References” for links to the Oracle grid-engine web-site. A direct successor of Sun Grid Engine 6.2u5 is the Open Grid Scheduler. This package is available for free and is included in your VWF tar package. The instructions below are referring to the Open Grid Scheduler.

Note: If you already have an installation of either Sun Grid Engine 6.2u5 or Oracle Grid Engine, you can continue to use these packages with VWF. No further installation is necessary.

Grid Engine consists of several daemons, which must be running on the hosts of the cluster. These daemons are the `qmaster`, the `scheduler`, and the `exec` daemons. You must nominate one host as the Grid Engine master host. This host runs the `qmaster` and the `scheduler` daemon. Additionally, on every host, which shall be used to execute jobs, the `exec` daemon must be running. You can also install the `exec` daemon on the master host if you want to run jobs on this host too. Note that you can install the Grid Engine system on a single host only. In this case, however, it is recommended you use the Silvaco Simple Queue instead.

These instructions are a cut and modified version of the install procedure explained in the N1 Grid Engine 6 Installation Guide found in Section B.7 “References”. If you require additional information, it will be in that guide. These instructions will occasionally refer to the N1 Grid Engine 6 Installation Guide. These instructions will also be a quick-start reference for setting up the Open Grid Scheduler on the single machine.

B.2 Open Grid Scheduler – Installation with the GUI Installer

The Open Grid Scheduler (OGS) package shipped with this version of VWF comes with a graphical installer (GUI installer), which simplifies the installation process. An example of how OGS can be installed on a single host is given below.

B.2.1 Prerequisites

Before you can run the installer, please make sure you login as root user. Next, you need to select a location where the OGS tar files need to be untarred. Here, the directory `/build/grid/ogs` was chosen. There are two files that need to be untarred. After changing to the directory `/build/grid/ogs`, please enter:

```
tar xvzf /site/alpha/lib/vwf/2.10.4.R/common/ogs-2011.11p1-bin-linux-x64.tar.gz

tar xvzf /site/alpha/lib/vwf/2.10.4.R/common/ogs-2011.11p1-common.tar.gz
```

Instead of `/site/alpha` as shown above, you must supply the path where you actually installed VWF on your system. Before you can proceed to starting the GUI installer, make sure you have got `java` installed and in your path:

```
[root@lannach ogs]# which java

/usr/bin/java


[root@lannach ogs]# java -version

java version "1.4.2"

gcj (GCC) 3.4.6 20060404 (Red Hat 3.4.6-11)

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This is free software; see the source for copying conditions.
There is NO warranty; not even for MERCHANTABILITY or FITNESS FOR A
PARTICULAR PURPOSE.
```

No particular version of java is required by the GUI installer.

B.2.2 Running the GUI Installer

You can start the installer as follows:

```
./start_gui_installer
```

This will open the window as shown in Figure B-1.

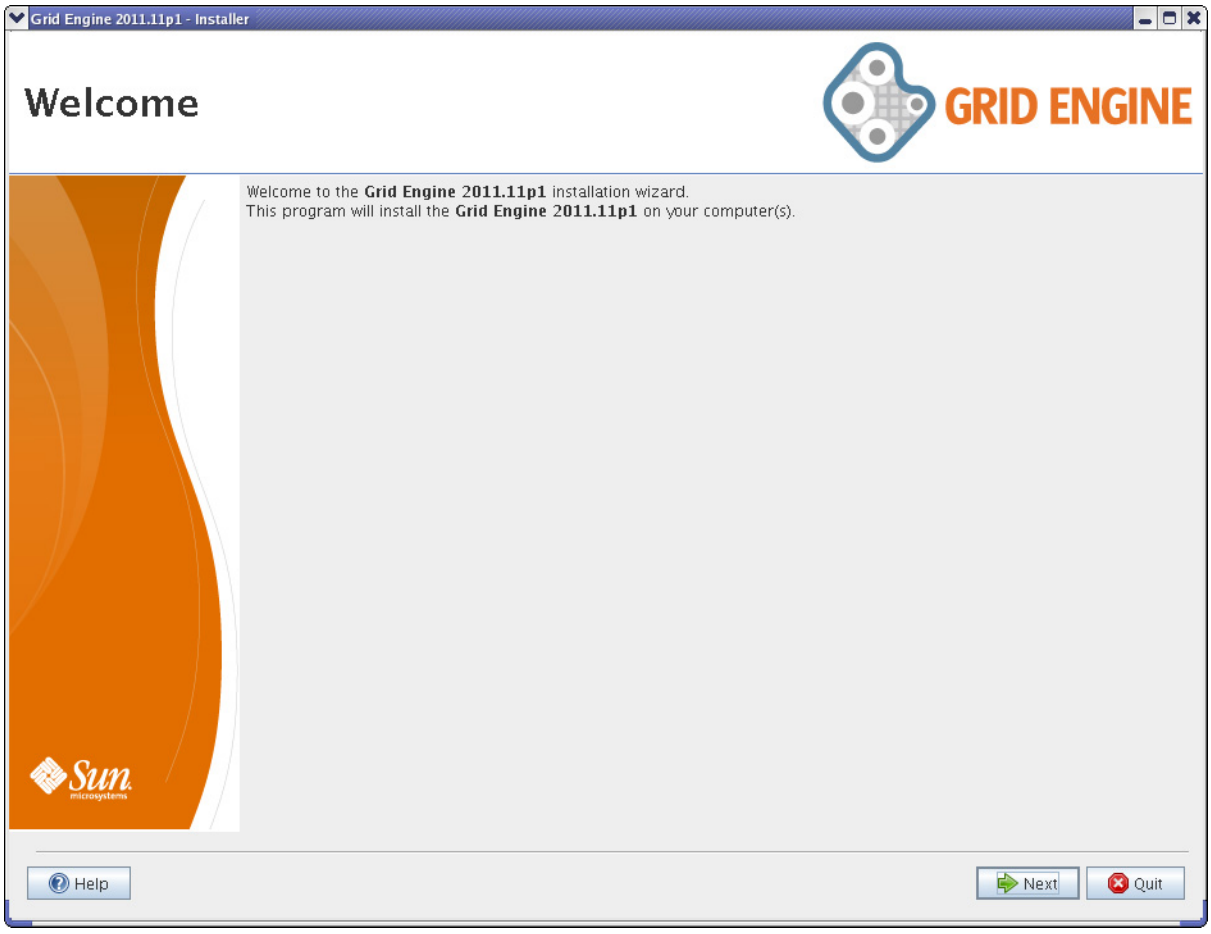

Figure B-1 OGS Installation – GUI Installer Main Screen

Clicking **Next** will show a dialog where you have to accept the licensing agreements as shown in Figure B-2.

Grid Engine 2011.11p1 - Installer
Licensing Agreements
GRID ENGINE
Please read the following license agreement carefully:
SUN INDUSTRY STANDARDS SOURCE LICENSE
Version 1.2
1.0 DEFINITIONS
1.1 Commercial Use means distribution or otherwise making the Original Code available to a third party.
1.2 Contributor Version means the combination of the Original Code, and the Modifications made by that particular Contributor.
1.3 Electronic Distribution Mechanism means a mechanism generally accepted in the software development community for the electronic transfer of data.
1.4 Executable means Original Code in any form other than Source Code.
1.5 Initial Developer means the individual or entity identified as the Initial Developer in the Source Code notice required by Exhibit A.
1.6 Larger Work means a work which combines Original Code or portions thereof with code not governed by the terms of this License.
1.7 License means this document.
1.8 Licensable means having the right to grant, to the maximum extent possible, whether at the time of the initial grant or subsequently acquired, any and all of the rights conveyed herein.
1.9 Modifications means any addition to or deletion from the substance or structure of either the Original Code or any previous Modifications. A Modification is:
A. Any addition to or deletion from the contents of a file containing Original Code or previous Modifications.
I accept the terms of this license agreement.
I do not accept the terms of this license agreement.
Help
Previous
Next
Quit

Figure B-2 OGS Installation – License Agreement

Accepting the license by selecting **I accept the terms of this license agreement** and clicking next will bring you to the screen shown in Figure B-3. Here, you can select the type of installation (custom or express) and whether you want to install a qmaster host, an exec host, or both. We recommend to use the custom installation process as shown in Figure B-3. The default express installation will try to install security certificates, which will require additional software.

Note: The installation or use of security certificates for grid-engine is not covered by this manual.

Figure B-3 OGS Installation – Custom Installation

Clicking **Next** will bring you to the main configuration screen as shown in Figure B-4. You don't need to change anything here.

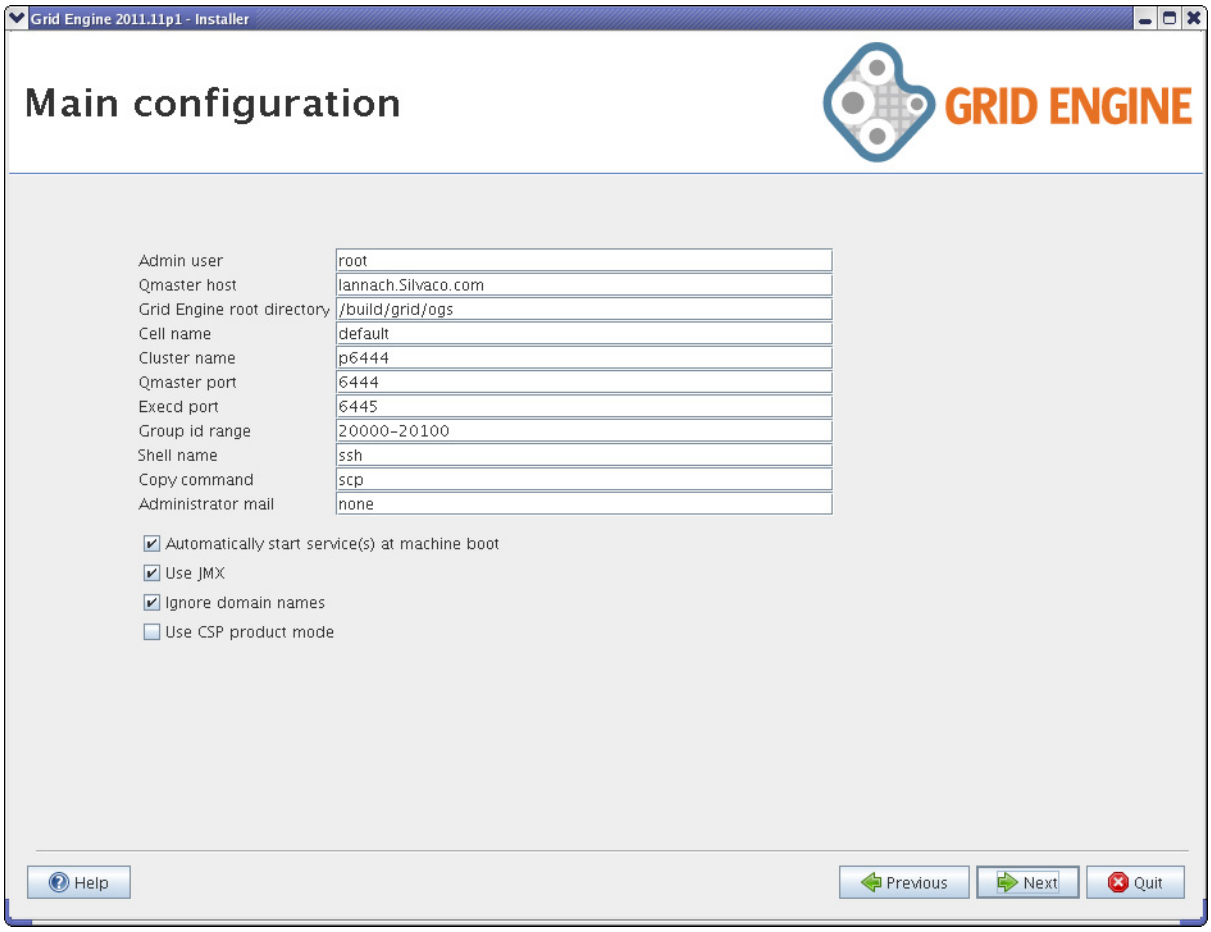

Figure B-4 OGS Installation – Main Configuration

Clicking next will bring you to the JMX configuration screen shown in Figure B-5. JMX is the Java management extension and allows you to use tools like the java console (jconsole) to connect to a running grid-engine master to display and change parameters. Please refer to the JMX documentation for full details on JMX. Please deselect the **enable SSL server authentication** to avoid security certificates being created and encryption being enforced.

Note: Encryption options shown here are only related to JMX not VWF in general and do not harm the basic grid-engine functionality in any way.

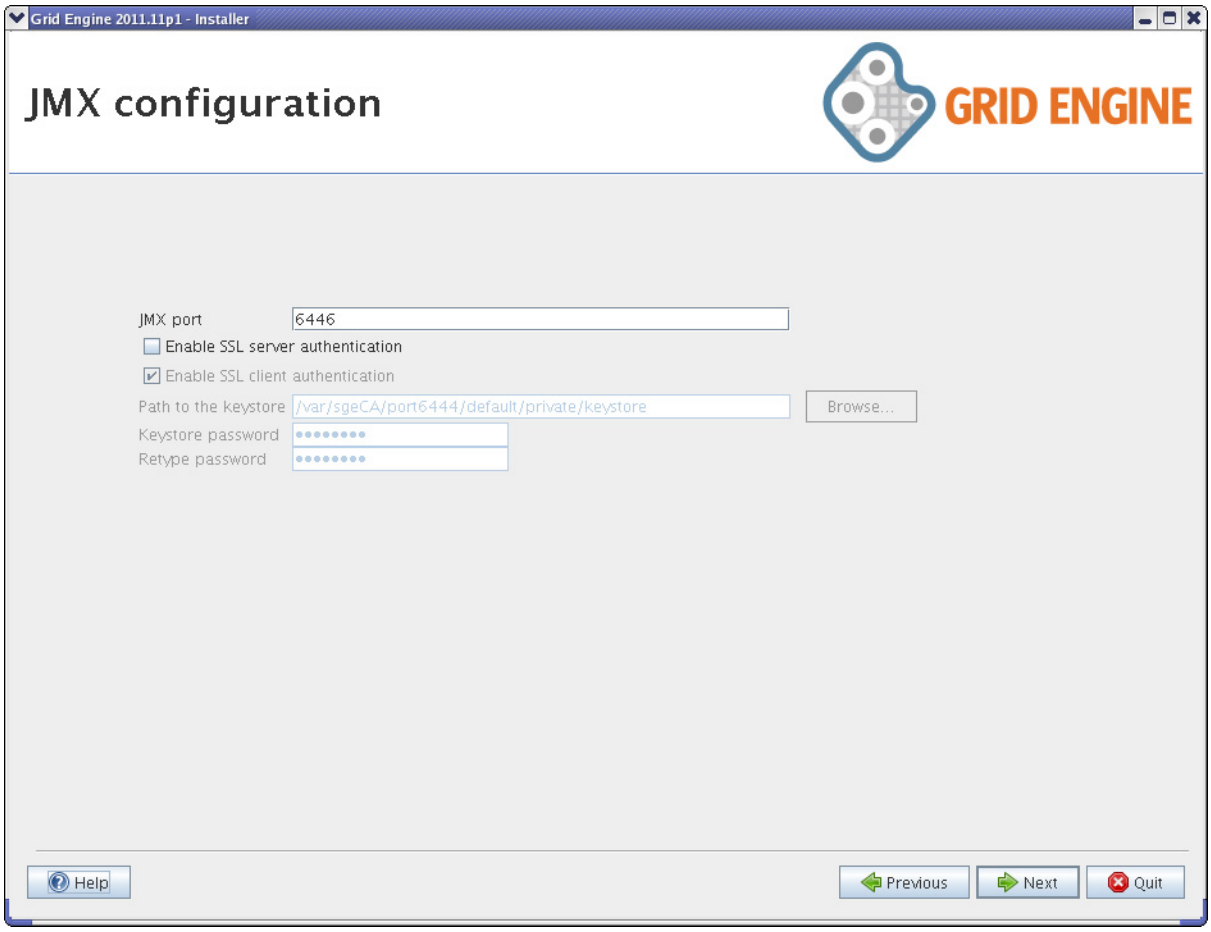

Figure B-5 OGS Installation – JMX Configuration

Clicking **Next** will bring you to the spooling configuration screen as shown in Figure B-6. You don't to change anything on this screen.

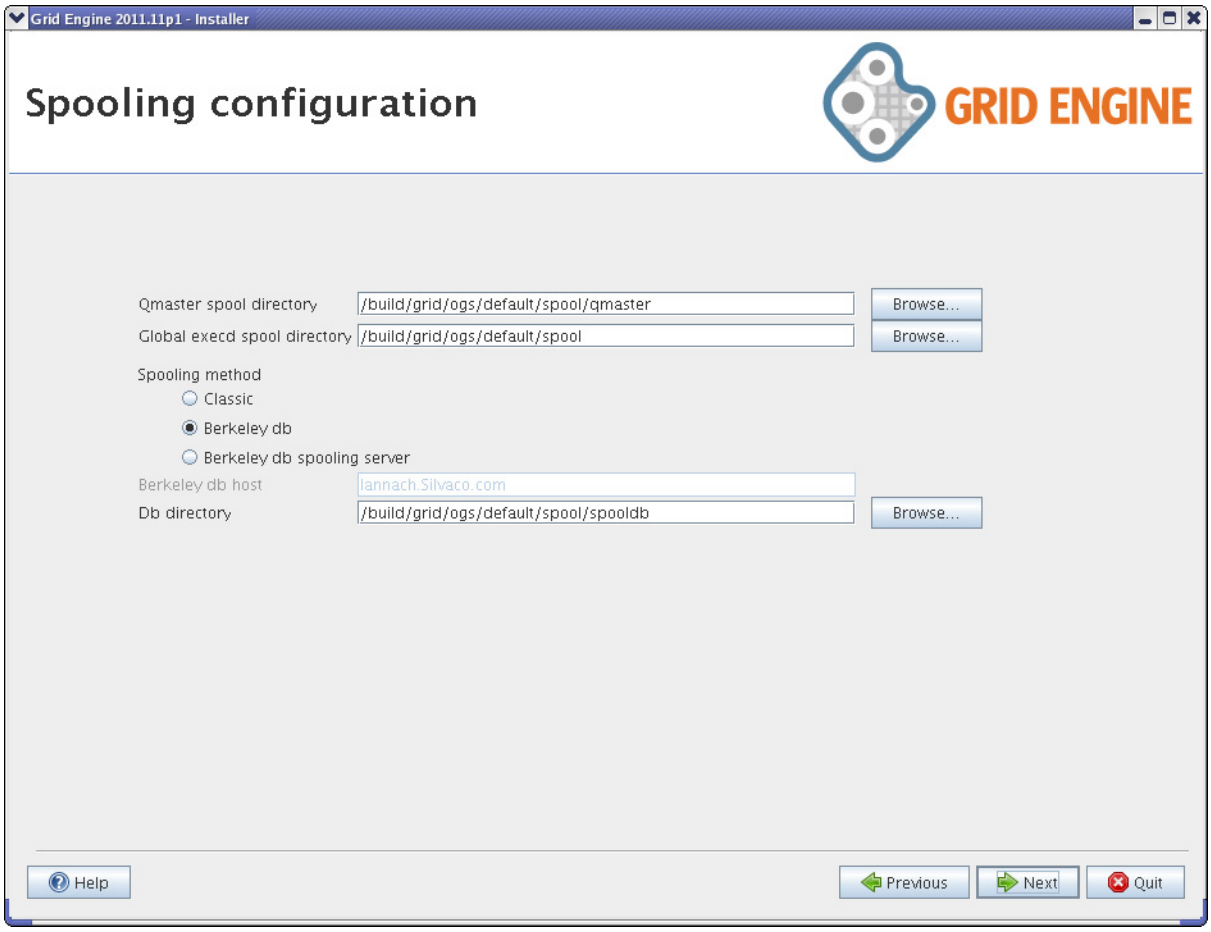

Figure B-6 OGS Installation – Spooling Configuration

Clicking **Next** will bring you to the SSL configuration screen as shown in Figure B-7. Again, you don't need to change anything on this screen.

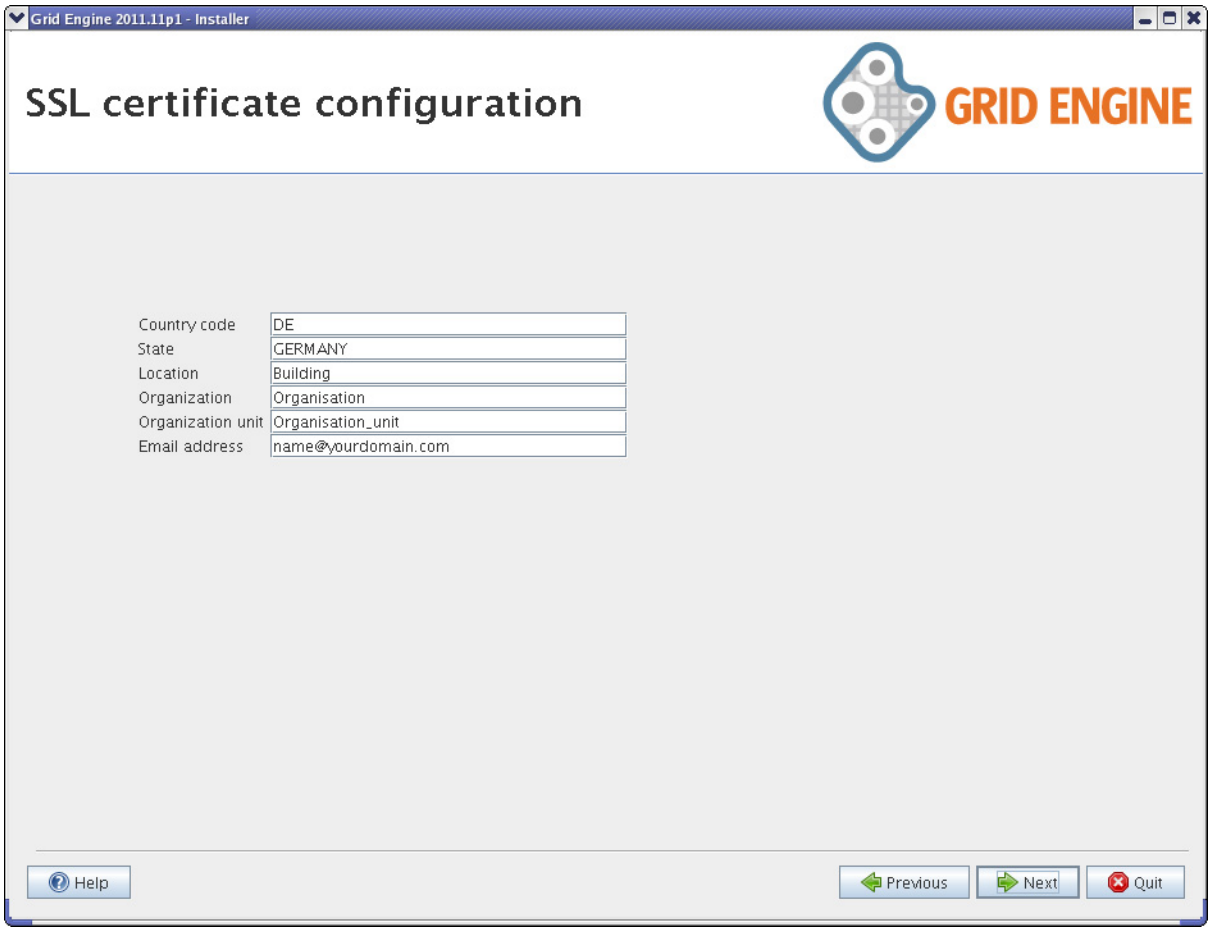

Figure B-7 OGS Installation – SSL Certificate

Clicking next will bring you to the host selection screen shown in Figure B-8. This screen allows you to add more hosts to be installed. Here, we are going to install OGS on a single host only. We want to install both qmaster and execution host. Please make sure that the option reading **Exec** is checked as shown in the screen shot.

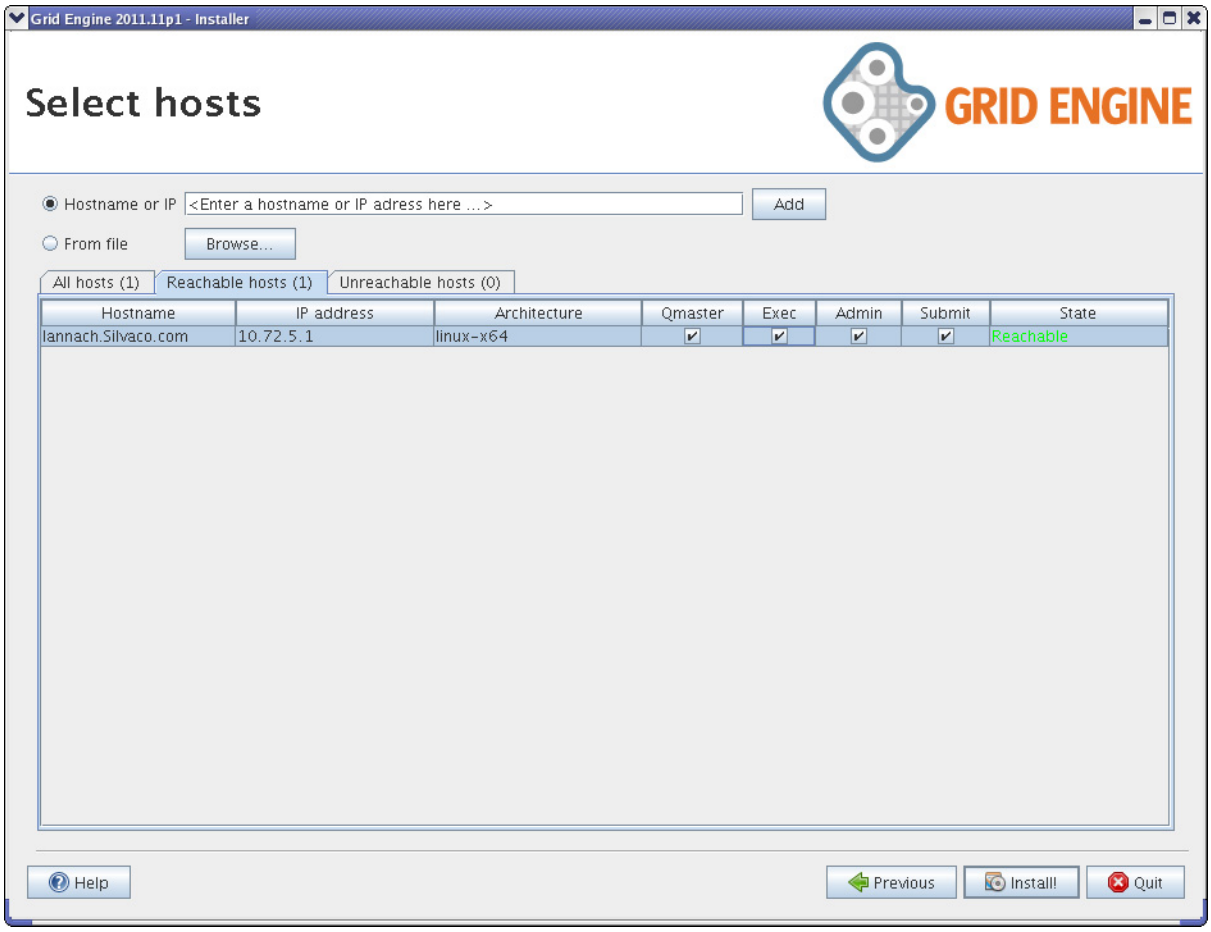

Figure B-8 OGS Installation – Select Hosts Screen

Clicking on **Install** will then start the actual installation process. Figure B-9 shows the output of the installation process in case of a successful installation.

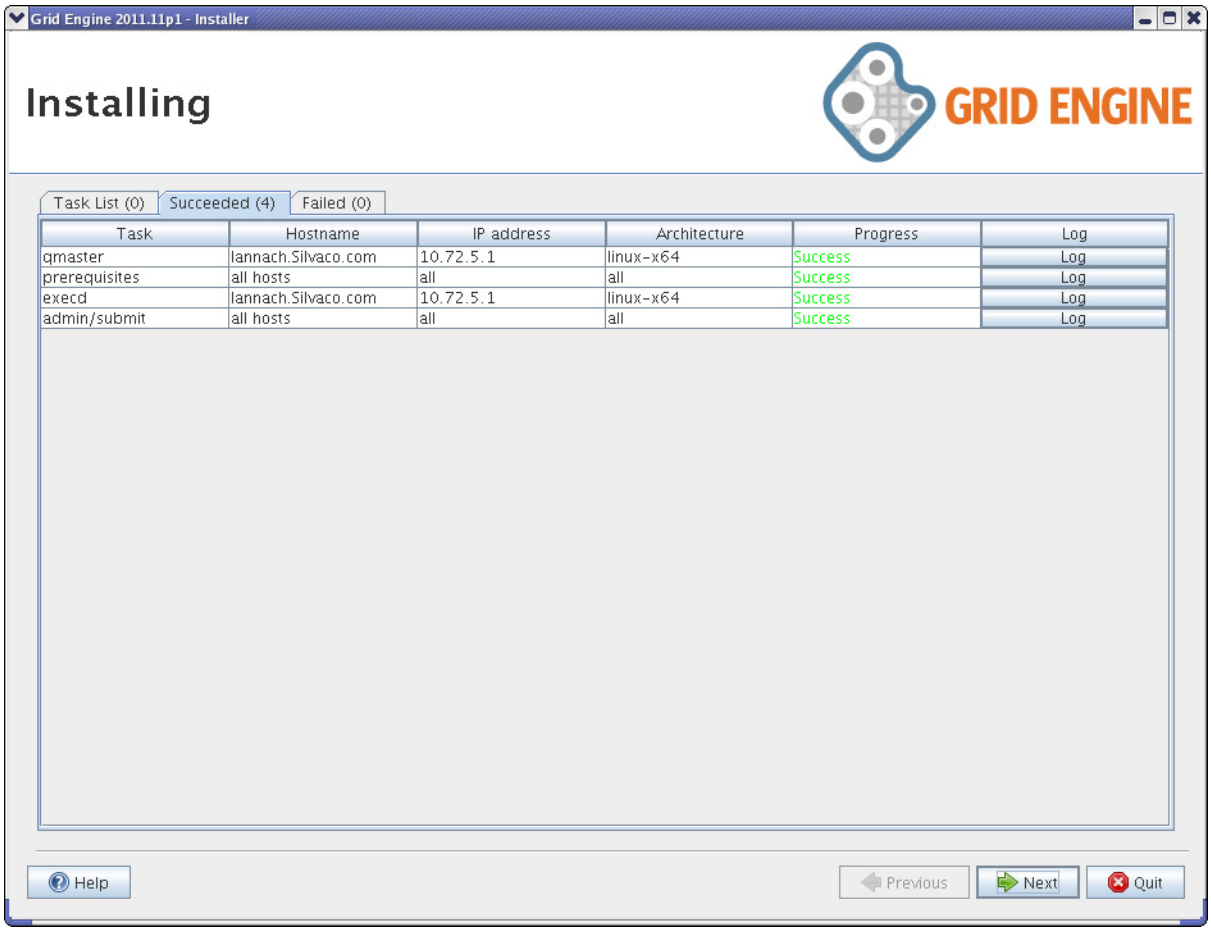

Figure B-9 OGS Installation – Successful Installation

Finally, the last screen (Figure B-10) displays a summary of the configuration of the newly installed grid-engine system.

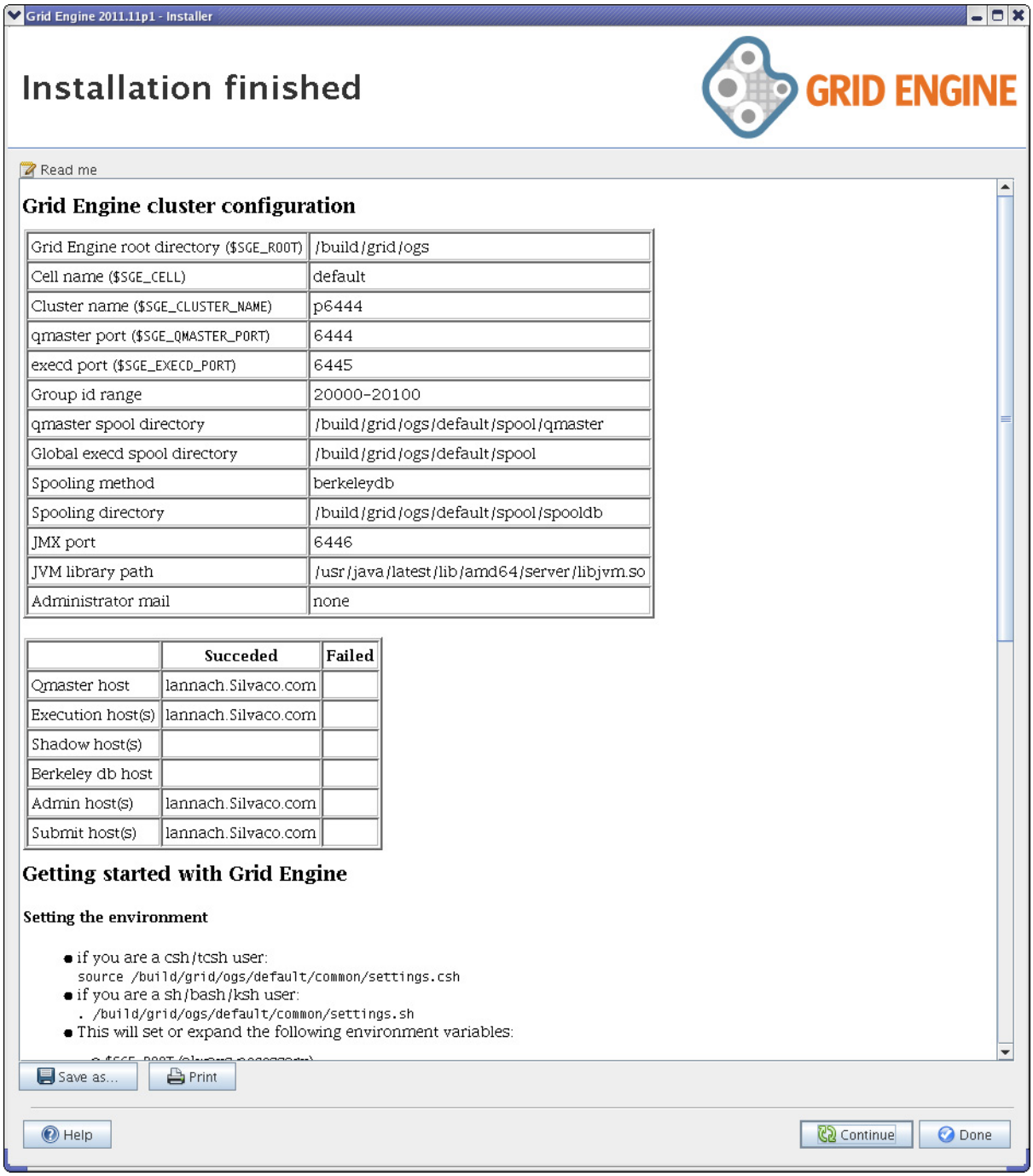

Figure B-10 OGS Installation – Summary

The system is now ready to be used.

Note: In case you experience any troubles during the installation, you may need to manually remove configuration files or directories left behind by the installer. Please consult the grid-engine manuals for more details.

B.3 Manuals

This version of OGS contains a full set of manual pages for the grid-engine components. When you untarred the OGS files, the manual were put into the following location:

```
/build/grid/ogs/man
```

A man page can be opened by using the `man` command and supplying the man page on the command-line, for example, to open the qsub man page you can type:

```
man /build/grid/ogs/man/man1/qsub.1
```

which will open the man page as follows:

```
SUBMIT(1)                                          Grid Engine User Commands
SUBMIT(1)


NAME
       qsub   -  submit a batch job to Grid Engine.
       qsh    -  submit an interactive X-windows session to Grid Engine.
       qlogin -  submit an interactive login session to Grid Engine.
       qrsh   -  submit an interactive rsh session to Grid Engine.
       qalter -  modify a pending or running batch job of Grid Engine.
       qresub -  submit a copy of an existing Grid Engine job.


SYNTAX
       qsub [ options ] [ command | -- [ command_args ]]
       qsh [ options ] [ -- xterm_args ]
       qlogin [ options ]
       qrsh [ options ] [ command [ command_args ]]
       qalter [ options ] wc_job_range_list [ -- [ command_args ]]
       qalter [ options ] -u user_list | -uall [ -- [ command_args ]]
       qresub [ options ] job_id_list


DESCRIPTION
Qsub  submits batch jobs to the Grid Engine queuing system. Grid Engine
supports single- and multiple-node jobs. Command can be a....
```

Alternatively, you can configure the `MANPATH` accordingly. Please refer to the documentation of the man command for further details.

B.4 Installation using the Traditional Method

Below, a description is given of how the grid-engine system can be installed without the GUI installer. The instructions below are valid for both, the original Sun Grid-Engine SGE-6.2u5 as well as the newer Open Grid Scheduler (all versions).

B.4.1 Product Manuals

These manuals are found in Section B.7 “References” in the docs directory to accompany the software. It is recommended that you make yourself familiar with these manuals. See the table below for the names of these manuals.

Manual	Description
`install_guide817-6118.pdf`	Install guide. This contains more information and explains the installation options in greater depth than this document.
`install_guide817-6118.pdf`	Install guide. This contains more information and explains the installation options in greater depth than this document.
`users_guide817-6117.pdf`	Users Guide. This explains how to run a job on the Grid Engine.
`admin_guide817-5677.pdf`	Administrators guide. This explains how to administer and maintain the system.
`release_notes817-5678.pdf`	Additional release notes.

B.4.2 Initial Set Up

1. Log in to the machine as root.
2. Create the directory:

   ```
   mkdir /var/opt/GRID
   ```

3. Locate the software (see Section B.7 “References”).
4. Copy over the required tar files to `/var/opt/GRID` and extract files.

   ```
   unzip sge62u1_linux24-i586_targz.zip
   tar xzvpf sge-6_2u1-bin-linux24-i586.tar.gz
   ```

5. Set up the TCP/IP services for the grid engine software.

   Add the correct ports to the `/etc/services` file or your NIS services map. The following example shows how you can append your `/etc/services` file.

   ```
   #Sun Grid Engine
   sge_qmaster 536/tcp
   sge_execd 537/tcp
   ```

6. Set the `$SGE_ROOT` environment variable as follows:

   ```
   SGE_ROOT=/var/opt/GRID; export SGE_ROOT
   ```

B.4.3 Install the Master Host (qmaster)

More details on the Master Host installation process can be found on pages 28 - 40 of the N1 Grid Engine 6 Installation Guide.

1. Change directory to the installation directory:

   ```
   cd /var/opt/GRID
   ```

2. Type the `install_qmaster` command.

   This command starts the master host installation procedure. You will be asked several questions, and you may be required to run some administrative actions. The instructions will show the typical output you should expect to see during the setup.

   ```
   ./install_qmaster
   Welcome to the Grid Engine installation
   ---------------------------------------
   Grid Engine qmaster host installation
   -------------------------------------
   ```

   Before you continue with the installation, please read these hints.

- Your terminal window should have a size of at least 80×24 characters.
- The INTR character is often bound to the key Ctrl-C. The term `>Ctrl-C<` is used during the installation if you have the possibility to abort the installation. The qmaster installation procedure will take approximately 5-10 minutes.

```
Hit <RETURN> to continue >>
```

3. Choose an administrative account owner.

   ```
   Choosing Grid Engine admin user account
   ---------------------------------------
   ```

   You may install Grid Engine that all files are created with the user id of an unprivileged user.

   This will make it possible to install and run Grid Engine in directories where user `>root<` has no permissions to create and write files and directories.

   - Grid Engine still has to be started by the user `>root<`.
   - This directory should be owned by the Grid Engine administrator.

   ```
   Do you want to install Grid Engine under a user id other than
   >root< (y/n)     [y] >> n Installing Grid Engine as user >root<?
   Hit <RETURN> to continue >>
   ```

4. Verify the sge-root directory setting.

   ```
   Checking $SGE_ROOT directory
   ----------------------------
   The Grid Engine root directory is:
   $SGE_ROOT = /var/opt/GRID
   ```

If this directory is not correct (e.g., it may contain an automounter prefix), enter the correct path to this directory or hit <RETURN> to use the default [/var/opt/GRID] >>.

```
Your $SGE_ROOT directory: /var/opt/GRID

Hit <RETURN> to continue >>
```

5. Set up the TCP/IP services for the Grid Engine software.

```
Grid Engine TCP/IP communication service

----------------------------------------
```

The port for sge_qmaster is currently set as service.

```
   sge_qmaster service set to port 536
```

Now you can set/change the communication ports by using the >shell environment<. You can also configure it through a network service, which is configured in local >/etc/service<, >NIS< or >NIS+<, and add an entry in the form:

```
    sge_qmaster <port_number>/tcp
```

to your services database. Make sure you use an unused port number.

Do the following to configure the Grid Engine communication ports.

- Use the >shell environment<: [1].
- Use a network service like >/etc/service<, >NIS/NIS+<: [2] (default: 2) >>.

```
Hit <RETURN> to continue >>

Grid Engine TCP/IP service >sge_qmaster<

----------------------------------------
```

Use the service:

```
   sge_qmaster
```

for communication with Grid Engine.

```
Hit <RETURN> to continue >>

Grid Engine TCP/IP communication service

----------------------------------------
```

The port for sge_execd is currently set as service.

```
   sge_execd service set to port 537
```

Now you can set/change the communication ports by using the >shell environment<. You can also configure it through a network service, which is configured in local >/etc/service<, >NIS< or >NIS+<, and add an entry in the form:

```
    sge_execd <port_number>/tcp
```

to your services database. Make sure you use an unused port number.

Do the following to configure the Grid Engine communication ports.

- Use the >shell environment<: [1].
- Use a network service like >/etc/service<, >NIS/NIS+<: [2] (default: 2) >>.

```
Hit <RETURN> to continue >>
```

```
Grid Engine TCP/IP communication service
----------------------------------------
```

Use the service:

```
sge_execd
```

for communication with Grid Engine.

```
Hit <RETURN> to continue >>
```

6. Enter the name of your cell:

```
Grid Engine cells
-----------------
```

Grid Engine supports multiple cells. If you are not planning to run multiple Grid Engine clusters or if you don't know yet what is a Grid Engine cell, it is safe to keep the default cell name default.

If you want to install multiple cells, you can enter a cell name now.

The environment variable:

```
$SGE_CELL=<your_cell_name>
```

will be set for all further Grid Engine commands.

```
Enter cell name [default] >>
Using cell >default<.
Hit <RETURN> to continue >>
```

7. Enter unique cluster name.

The cluster name uniquely identifies a specific Open Grid Scheduler cluster. The cluster name must be unique throughout your organization. The name is not related to the OGS cell. The cluster name must start with a letter (`[A-Za-z]`), followed by letters, digits (`[0-9]`), dashes (`-`) or underscores (_).

```
Enter new cluster name or hit <RETURN>
to use default [p536] >> VWF2009

Your $SGE_CLUSTER_NAME: VWF2009

Hit <RETURN> to continue >>
```

8. Specify a spool directory:

```
Grid Engine qmaster spool directory
-----------------------------------
```

The qmaster spool directory is the place where the qmaster daemon stores the configuration and the state of the queuing system. User `>root<` on this host must have read/write access to the qmaster spool directory.

If you want install shadow master hosts or start the qmaster daemon on other hosts, the account on the shadow master hosts also needs read/write access to this directory. See the corresponding section in the Grid Engine Installation and Administration Manual for details.

The following directory:

```
[/var/opt/GRID/default/spool/qmaster]
will be used as qmaster spool directory by default!
Do you want to select another qmaster spool directory (y/n) [n] >>
n
```

9. Set the correct file permissions.

```
Verifying and setting file permissions
---------------------------------------
Did you install this version with >pkgadd< or did you already
verify and set the file permissions of your distribution (y/n) [y]
>> n
Verifying and setting file permissions
---------------------------------------
```

You can now verify and set the file permissions of your Grid Engine distribution. This may be useful since, due to unpacking and copying of your distribution, your files may be inaccessible to other users.

We will set the permissions of directories and binaries to 755, which means executable are accessible for the world and for ordinary files to 644, which means readable for the world.

```
Do you want to verify and set your file permissions (y/n) [y] >> y
Verifying and setting file permissions and owner in >3rd_party<
Verifying and setting file permissions and owner in >bin<
Verifying and setting file permissions and owner in >ckpt<
Verifying and setting file permissions and owner in >examples<
Verifying and setting file permissions and owner in >inst_sge<
Verifying and setting file permissions and owner in >install_execd<
Verifying and setting file permissions and owner in
>install_qmaster<
Verifying and setting file permissions and owner in >lib<
Verifying and setting file permissions and owner in >mpi<
Verifying and setting file permissions and owner in >pvm<
Verifying and setting file permissions and owner in >qmon<
Verifying and setting file permissions and owner in >util<
Verifying and setting file permissions and owner in >utilbin<
Verifying and setting file permissions and owner in >catman<
```

```
Verifying and setting file permissions and owner in >doc<
Verifying and setting file permissions and owner in >include<
Verifying and setting file permissions and owner in >man<
```

Your file permissions are set.

```
Hit <RETURN> to continue >>
```

10. Specify whether all of your grid engine system hosts are located in a single DNS domain.

```
Select default Grid Engine hostname resolving method
-----------------------------------------------------
```

Are all hosts of your cluster in one DNS domain? If this is the case the hostnames:

`>hostA<` and `>hostA.foo.com<`

will be treated as equal because the DNS domain name `>foo.com<` is ignored when comparing hostnames.

```
Are all hosts of your cluster in a single DNS domain (y/n) [y] >> y
Ignoring domainname when comparing hostnames.
Hit <RETURN> to continue >>
```

11. Making directories

```
Making directories
------------------
creating directory: /var/opt/GRID/default/spool/qmaster
creating directory: /var/opt/GRID/default/spool/qmaster/
job_scripts
Hit <RETURN> to continue >>
```

12. Specify whether you want to use classic spooling or Berkeley DB

```
Setup spooling
--------------
```

Your OGS binaries are compiled to link the spooling libraries during runtime (dynamically). So you can choose between Berkeley DB spooling and Classic spooling method. Please choose a spooling method: `(berkeleydb|classic)` or `[berkeleydb] >>`.

```
Hit <RETURN> to continue >>
```

The Berkeley DB spooling method provides two configurations.

- Local spooling: The Berkeley DB spools into a local directory on this host (qmaster host). This setup is faster, but you can't setup a shadow master host.
- Berkeley DB Spooling Server: If you want to setup a shadow master host, you need to use Berkeley DB Spooling Server. In this case, choose a host with a configured RPC service. The qmaster host connects through RPC to the Berkeley DB. This setup is more fail safe but results in a potential security hole. RPC communication (as used by Berkeley DB) can be easily compromised. Please only use this alternative if your site is secure or if

you are not concerned about security. Check the installation guide for further advice on how to achieve fail-safety without compromising security.

```
Do you want to use a Berkeley DB Spooling Server? (y/n) [n] >> n

Hit <RETURN> to continue >>

Berkeley Database spooling parameters

-------------------------------------
```

Please enter the Database Directory now, even if you want to spool locally.

```
Default: [/var/opt/GRID/default/spool/spooldb] >>

Hit <RETURN> to continue >>
```

13. Enter a group ID range

```
Grid Engine group id range

-------------------------
```

When jobs are started under the control of the Grid Engine, an additional group id is set on platforms that do not support jobs. This is done to provide maximum control for Grid Engine jobs.

This additional UNIX group id range must be an unused group id's in your system. Each job will be assigned a unique id during the time it is running. Therefore, you need to provide a range of id's that will be assigned dynamically for jobs. The range must be big enough to provide enough numbers for the maximum number of Grid Engine jobs running at a single moment on a single host. For example, a range like `>20000-20100<` means that Grid Engine will use the group ids from 20000-20100 and provides a range for 100 Grid Engine jobs at the same time on a single host.

You can change at any time the group id range in your cluster configuration.

```
Please enter a range >> 20000-20100

Using >20000-20100< as gid range. Hit <RETURN> to continue >>
```

14. Verify the spooling directory for the execution daemon

```
Grid Engine cluster configuration

--------------------------------
```

```
Please give the basic configuration parameters of your Grid Engine

installation:

<execd_spool_dir>
```

The pathname of the spool directory of the execution hosts. User `>root<` must have the right to create this directory and to write into it.

```
Default: [/var/opt/GRID/default/spool] >>

Hit <RETURN> to continue >>
```

15. Enter the email address of the user who should receive problem reports.

```
Grid Engine cluster configuration (continued)

-------------------------------------------
```

```
<administrator_mail>
```

The email address of the administrator to whom problem reports will be sent. It's recommended to configure this parameter. You may use >none< if you do not wish to receive administrator mail.

```
Please enter an email address in the form >user@foo.com<.

Default: [none] >> me@my.domain
```

16. Verify the configuration parameters.

The following parameters for the cluster configuration were configured:

```
execd_spool_dir /var/opt/GRID/default/spool

administrator_mail me@my.domain

Do you want to change the configuration parameters (y/n) [n] >> n

Creating local configuration

----------------------------

Creating >act_qmaster< file

Adding default complex attributes

Adding default parallel environments (PE)

Adding SGE default usersets

Adding >sge_aliases< path aliases file

Adding >qtask< qtcsh sample default request file

Adding >sge_request< default submit options file

Creating >sgemaster< script

Creating >sgeexecd< script

Creating settings files for >.profile/.cshrc<


Hit <RETURN> to continue >>
```

17. Specify whether you want the daemons to start when the system is booted.

```
qmaster startup script

----------------------

We can install the startup script that will

start qmaster at machine boot (y/n) [y] >> y


cp       /var/opt/GRID/default/common/sgemaster       /etc/init.d/
sgemaster.VWF2009

/usr/lib/lsb/install_initd /etc/init.d/sgemaster.VWF2009


Hit <RETURN> to continue >>
```

```
Grid Engine qmaster startup

---------------------------

Starting qmaster daemon. Please wait ...

   starting sge_qmaster


Hit <RETURN> to continue >>
```

18. Identify the hosts that you will later install as execution hosts.

```
Adding Grid Engine hosts

------------------------
```

Please now add the list of hosts, where you will later install your execution daemons. These hosts will be also added as valid submit hosts. Please enter a blank separated list of your execution hosts. You may press <RETURN> if the line is getting too long. Once you are finished simply press <RETURN> without entering a name.

You also may prepare a file with the hostnames of the machines where you plan to install Grid Engine. This may be convenient if you are installing Grid Engine on many hosts.

```
Do you want to use a file which contains the list of hosts (y/n) [n]
>> n

Adding admin and submit hosts

----------------------------

Please enter a blank seperated list of hosts.
```

Stop by entering <RETURN>. You may repeat this step until you are entering an empty list. You will see messages from Grid Engine when the hosts are added.

```
Hit <RETURN> to continue >>

Host(s):

Hit <RETURN> to continue >>

Finished Adding Hosts

Hit <RETURN> to continue >>
```

If you want to use a shadow host, then add it to the list of administrative hosts.

If you are not sure, you can add or remove hosts after the installation with `<qconf -ah hostname>` for adding and `<qconf -dh hostname>` for removing.

```
Attention: This is not the shadow host installation

procedure.

You still have to install the shadow host separately

Do you want to add your shadow host(s) now? (y/n) [y] >> n


Creating the default <all.q> queue and <allhosts> hostgroup

-------------------------------------------------------

root@{hostname} added "@allhosts" to host group list
```

```
root@{hostname} added "all.q" to cluster queue list
Hit <RETURN> to continue >>
```

19. Select a scheduler profile.

```
Scheduler Tuning
----------------
```

The details on the different options are described in the manual.

```
Configurations
--------------
1) Normal
Fixed interval scheduling, report scheduling information,
actual + assumed load
2) High
Fixed interval scheduling, report limited scheduling information,
actual load
3) Max
Immediate Scheduling, report no scheduling information,
actual load
Enter the number of your prefered configuration and hit <RETURN>!
Default configuration is [1] >>
We're configuring the scheduler with >Normal< settings!
Do you agree? (y/n) [y] >> y
```

20. Create the environment variables for use with the grid engine software.

```
Using Grid Engine
-----------------
```

You should now enter the command:

```
source /var/opt/GRID/default/common/settings.csh
```

if you are a csh/tcsh user or

```
# . /var/opt/GRID/default/common/settings.sh
```

if you are a sh/ksh user.

This will set or expand the following environment variables:

```
$SGE_ROOT (always necessary)
$SGE_CELL (if you are using a cell other than >default<)
$SGE_QMASTER_PORT (if you haven't added the service >sge_qmaster<)
$SGE_EXECD_PORT (if you haven't added the service >sge_execd<)
$PATH/$path (to find the Grid Engine binaries)
$MANPATH (to access the manual pages)
```

```
Hit <RETURN> to see where Grid Engine logs messages >>
```

Once you press <RETURN>, the installation process is complete. Several screens of information will be displayed before the script exits. Now source appropriate settings file to set up environment variables as described above.

If you don't want source setting file each time you log on grid engine host, you should insert settings file into the shell rc files.

21. Source the settings files.

    Check which shell you are using:

    ```
    echo $SHELL
    ```

    If the output is:

    ```
    bash then add in /etc/bashrc
    source /var/opt/GRID/default/common/settings.sh

    csh/tcsh then add in etc/csh.cshrc
    source /var/opt/GRID/default/common/settings.csh
    ```

B.4.4 Install the Execution Host (execd)

More details on Execution Host installation process can be found on pages 41 - 49 of the N1 Grid Engine 6 Installation Guide.

1. Change the directory to the installation directory:

   ```
   cd /var/opt/GRID
   ```

2. Type the `install_execd` command.

   This command starts the execution host installation procedure. You will be asked several questions, and you may be required to run some administrative actions. The instructions will show the typical output you should expect to see during the setup.

   ```
   ./install_execd
   Welcome to the Grid Engine execution host installation
   ------------------------------------------------------
   ```

If you haven't installed the Grid Engine qmaster host yet, you must execute this step (with `>install_qmaster<`) prior the execution host installation. For a successful installation, you need a running Grid Engine qmaster. It is also necessary that this host is an administrative host.

You can verify your current list of administrative hosts with the command:

```
# qconf -sh
```

You can add an administrative host with the command:

```
# qconf -ah <hostname>
```

The execution host installation will take approximately 5 minutes.

```
Hit <RETURN> to continue >>
```

3. Verify the sge-root directory setting.

```
Checking $SGE_ROOT directory
----------------------------
```

The Grid Engine root directory is:

```
$SGE_ROOT = /var/opt/GRID
```

If this directory is not correct (e.g., it may contain an automounter prefix), enter the correct path to this directory or hit <RETURN> to use default `[/var/opt/GRID] >>`.

```
Your $SGE_ROOT directory: /var/opt/GRID
Hit <RETURN> to continue >>
```

4. Enter the name of your cell(s)

```
Grid Engine cells
-----------------
```

Please enter cell name that you used for the qmaster installation or press <RETURN> to use default cell `>default< >>`.

```
Using cell: >default<
Hit <RETURN> to continue >>
Grid Engine TCP/IP communication service
----------------------------------------
The port for sge_execd is currently set as service.
   sge_execd service set to port 537

Hit <RETURN> to continue >>
```

5. Check execution host has been declared as an administration Host.

```
Checking hostname resolving
---------------------------
```

This hostname is known at qmaster as an administrative host.

```
Hit <RETURN> to continue >>
```

6. Specify whether you want to use a local spool directory.

```
Execd spool directory configuration
-----------------------------------
```

You defined a global spool directory when you installed the master host. You can use that directory for spooling jobs from this execution host. You can also define a different spool directory for this execution host.

```
ATTENTION: For most operating systems, the spool directory does not
have to
be located on a local disk. The spool directory can be located on a
network-accessible drive. However, using a local spool directory
provides
better performance.

FOR WINDOWS USERS: On Windows systems, the spool directory MUST be
located
on a local disk. If you install an execution daemon on a Windows
system
without a local spool directory, the execution host is unusable.

The spool directory is currently set to:
<</var/opt/GRID/default/spool/grid0>>

Do you want to configure a different spool directory
for this host (y/n) [n] >> n

Creating local configuration
----------------------------
root@grid0.Silvaco.COM     modified     "grid0.Silvaco.COM"     in
configuration list
Local configuration for host >grid0.Silvaco.COM< created.

Hit <RETURN> to continue >>
```

7. Specify whether you want execd to start automatically at boot time.

```
execd startup script
--------------------
We can install the startup script that will
start execd at machine boot (y/n) [y] >> y
cp/var/opt/GRID/default/common/sgeexecd/etc/init.d/
sgeexecd.VWF2009
/usr/lib/lsb/install_initd /etc/init.d/sgeexecd.VWF2009

Hit <RETURN> to continue >>

Grid Engine execution daemon startup
```

```
-----------------------------------
Starting execution daemon. Please wait ...
   starting sge_execd

Hit <RETURN> to continue >>
```

8. Specify a queue for this host

```
Adding a queue for this host
---------------------------
```

We can now add a queue instance for this host:

```
it is added to the >allhosts< hostgroup
the queue provides 2 slot(s) for jobs in all queues
referencing the >allhosts< hostgroup
```

You do not need to add this host now. But before running jobs on this host, add it to at least one queue.

```
Do you want to add a default queue instance for this host (y/n) [y]
>> y
root@{hostname} modified "@allhosts" in host group list
root@{hostname} modified "all.q" in cluster queue list
Hit <RETURN> to continue >>
```

Once you answer this question, the installation process is complete. Several screens of information will be displayed before the script exits. There is no need to source appropriate settings file to set up environment variables because we did it earlier. Grid Engine is ready to recieve jobs.

9. Do a quick test.

```
qsub -b yes /bin/ls
Your job 10209 ("ls") has been submitted

ls ls.*
ls.e10209  ls.o10209
```

The `.o` file should contain the output of `ls`.

If you get the following message:

```
Unable to run job: denied: host “grid0.silvaco” is not submit host.
```

then use `qconf -sh <hostname>` or use `qmon` GUI to add a submit host.

B.4.5 Install execd on another host

1. Share the Grid Engine root directory `/var/opt/GRID` on the master host.

   When logging onto the master host, do the following:

   ```
   cd /etc
   vi exports
   ```

   Add the following line to the file:

   ```
   /var/opt/GRID          *(rw,no_root_squash,sync)
   /etc/init.d/nfs start
   chkconfig --level 345 nfs on
   ```

2. Mount the Grid Engine root directory `/var/opt/GRID` on all execution hosts.

   On all execution hosts, do the following:

   ```
   cd /
   mkdir node0
   cd /etc
   vi auto.node0
   ```

   Add the following line to the file:

   ```
   GRID grid0:/var/opt/GRID
   vi auto.master
   ```

   Append the following line to the file:

   ```
   /node0 auto.node0
   /etc/init.d/autofs start
   /sbin/chkconfig --level 345 autofs on
   cd /var/opt
   ln -s /node0/GRID  GRID
   ```

3. Set up the TCP/IP services for the grid engine software.

   Add the correct ports to the `/etc/services` file or your NIS services map. The following example shows how you might append your `/etc/services` file:

   ```
   #Sun Grid Engine
   sge_qmaster 536/tcp
   sge_execd 537/tcp
   ```

4. Set the `$SGE_ROOT` environment variable

   ```
   SGE_ROOT=/var/opt/GRID; export SGE_ROOT
   ```

5. Source the settings files.

   Check which shell you are using:

   ```
   echo $SHELL
   ```

   If the output is:

```
bash then add in /etc/bashrc
source /var/opt/GRID/default/common/settings.sh
csh/tcsh then add in etc/csh.cshrc
source /var/opt/GRID/default/common/settings.csh
```

6. Add administrative host with the following command:

   ```
   qconf -ah <hostname>
   ```

   or use `qmon` GUI to add an admin host.

7. Type the `install_execd` command

   This command starts the execution host installation procedure. You are asked several questions, and you might be required to run some administrative actions. The instructions will show the typical output you should expect to see during the setup.

   ```
   ./install_execd
   Welcome to the Grid Engine execution host installation
   ------------------------------------------------------
   ```

   If you haven't installed the Grid Engine qmaster host yet, you must execute this step (with `>install_qmaster<`) prior the execution host installation. For a sucessfull installation, you need a running Grid Engine qmaster. It is also necessary that this host is an administrative host.

   You can verify your current list of administrative hosts with the command:

   ```
   # qconf -sh
   ```

   You can add an administrative host with the command:

   ```
   # qconf -ah <hostname>
   ```

   The execution host installation will take approximately 5 minutes.

   ```
   Hit <RETURN> to continue >>
   ```

8. Add submit host with the command:

   ```
   qconf -sh <hostname>
   ```

   or use `qmon` GUI to add a submit host.

B.5 Submitting Jobs

These instructions are a guide on what settings are necessary to submit jobs directly to a Grid Engine cluster. You don't need extra commands to use Grid Engine from within VWF. Before proceeding, please make sure Grid Engine has been installed as described above and that you are able to interactively run jobs on the grid.

To use Grid Engine please follow these steps:

1. Login to one of the submit hosts of your Grid Engine cluster by using telnet, ssh or rsh. Make sure you have the `DISPLAY` variable set to point to your workstation (from where you logged into the submit host). If you have several submit hosts, it does not matter which host you choose to run VWF. If your workstation is actually configured to be a submit host, you can skip this step.
2. Start VWF. The main VWF screen should show after a short delay. If it doesn't, please verify that VWF is available on your chosen submit host and double check the `DISPLAY` setting.
3. From the VWF main screen, select **Edit→Preferences**. A dialog as shown in Figure B-11 will appear. The left pane of this dialog displays a tree with various settings. Go to the **Grid** setting.

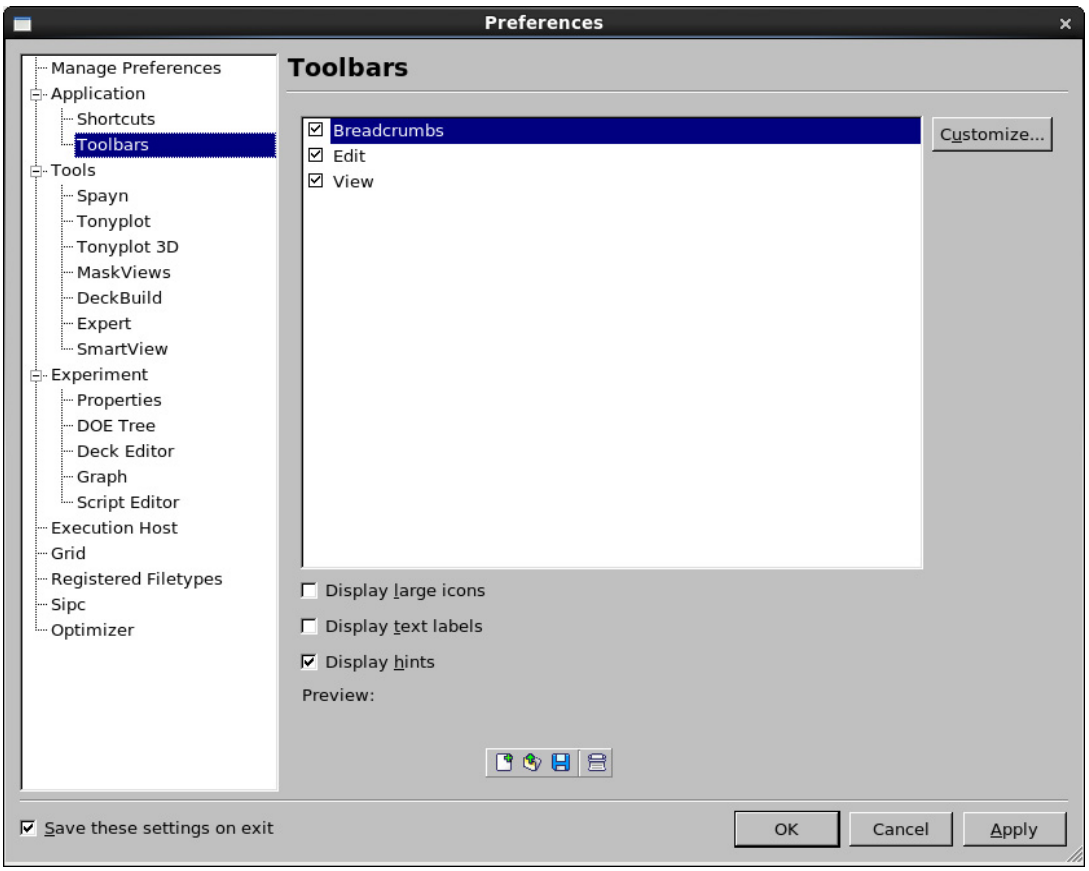

Figure B-11 Preferences Dialog

4. Figure B-12 displays the Grid Preferences pane. At the top of the pane, you can select the a profile containing settings for a particular grid type. This setting must read SGE **drmaa** in order to queue jobs into the Grid Engine system. Please change the setting accordingly.

5. The pane below the grid type setting allows you to specify options (Figure B-13), which will be passed to the Grid Engine system. These options are essentially identical to the ones as understood by the qsub command of Grid Engine. These options are passed to every job that is executed from VWF. They are optional. You don't need to set/change any of these options to use the Grid Engine with VWF. It is recommended to first try using the default settings before changing any options. Below is a list of options, which you may find useful. For a full set of options, please consult the `qsub` manual page.

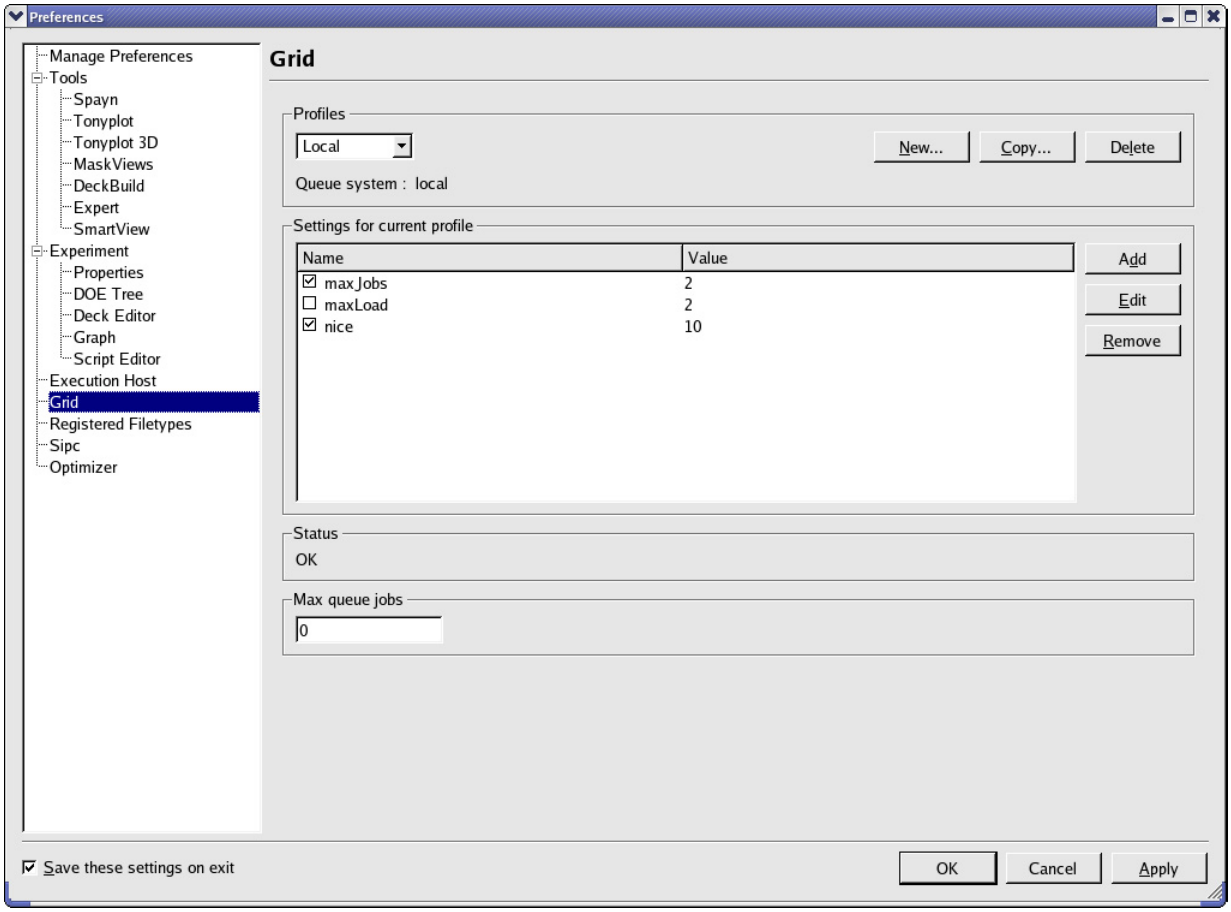

Figure B-12 Grid Preferences

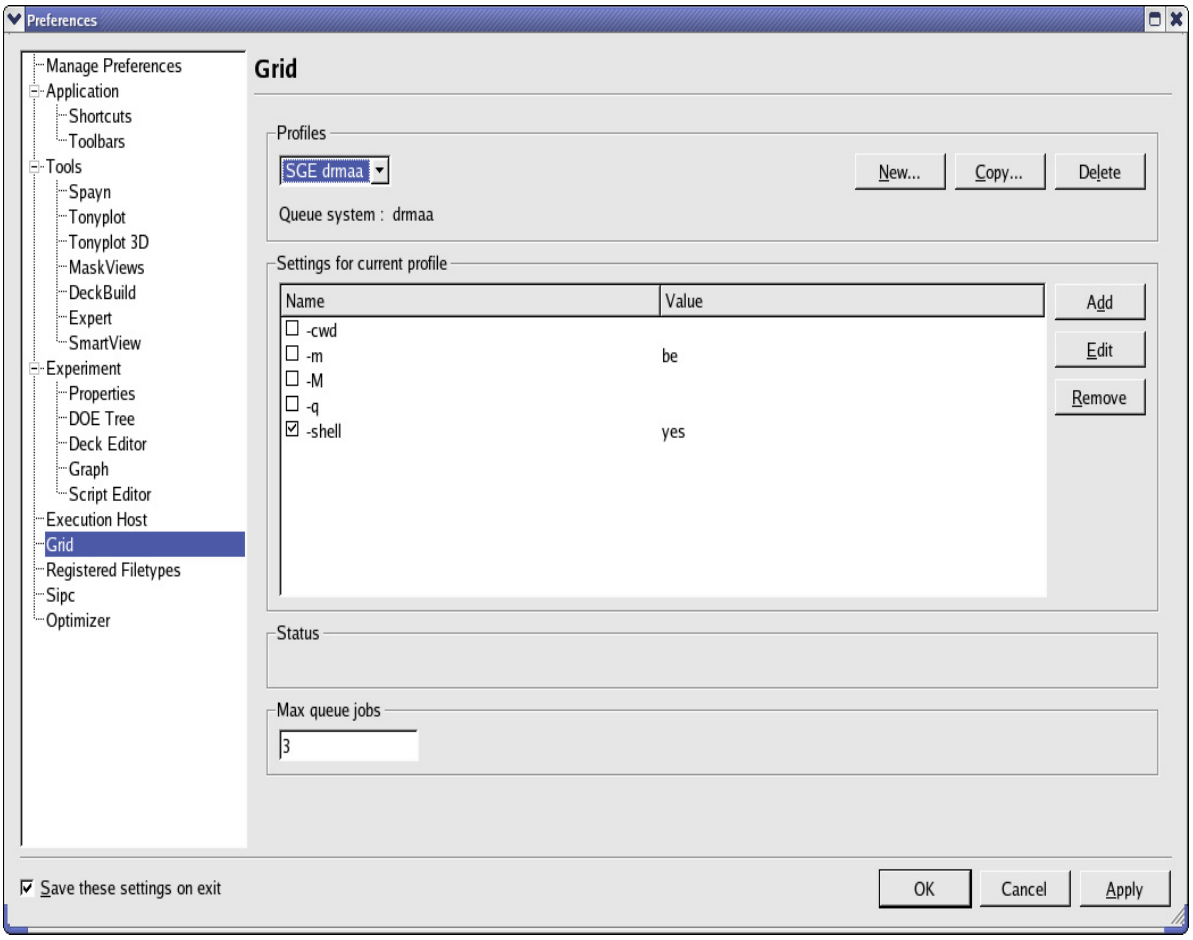

Figure B-13 SGE drmaa Preferences

Useful qsub Options

- `-m`: Allows you to activate email notifications on the job level. The option expects as argument the reason for which an email should be sent. Supported reasons are b (send email at beginning of the job), e (send email at the end of the job), a (send email in case job was aborted), s (send email when job was suspended), or n (no email is sent).
- `-M`: Specifies the email address to send emails to (only useful in case -m was specified).
- `-q`: Allows you to specify a queue other than the default.

6. Below the options settings, there's a brief status window. This will indicate the status of the OGS system once it was detected.
7. **Max queue jobs**: Use this field to limit the maximum number of jobs, which are added as active jobs into the OGS system. Jobs that would exceed this limit are still added into the system but are put on hold (state HOLD). As other jobs finish, jobs put on HOLD will become active (change from HOLD to PENDING) and will run whenever the scheduler decides it can run more jobs.

8. After having selected **SGE drmaa** type and you (optionally) have set the desired options, select **OK** on the dialog. A final dialog will appear indicating that you need to restart VWF whenever you change the grid type setting (Figure B-14). Press **OK** and then exit and restart VWF.

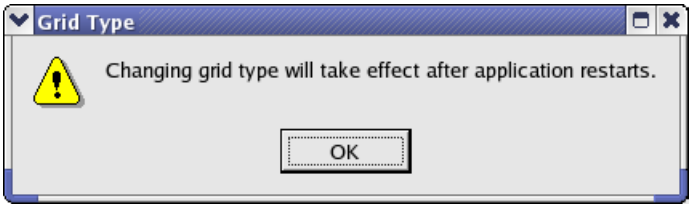

Figure B-14 Request to Restart VWF

9. You have now completed all required steps to configure VWF for Grid Engine usage.

Note: To allow an error free operation with Grid Engine, make sure that every host within the used Grid Engine cluster has read/write access to the central storage location, which was configured during the `vwf -install` step described in this manual. Please do not change the settings from the VWF GUI. If possible, please use the default settings suggested by the install procedure.

---

10. Possible error conditions:
    - **Open of an experiment fails and the dialog in Figure B-15 is shown**. This problem will occur if the `SGE_ROOT` environment of the Grid Engine was not set or wrongly set. As a solution, please add a command to source the Grid Engine `settings.sh` (or `settings.csh`) file from your login profile or manually source these scripts.

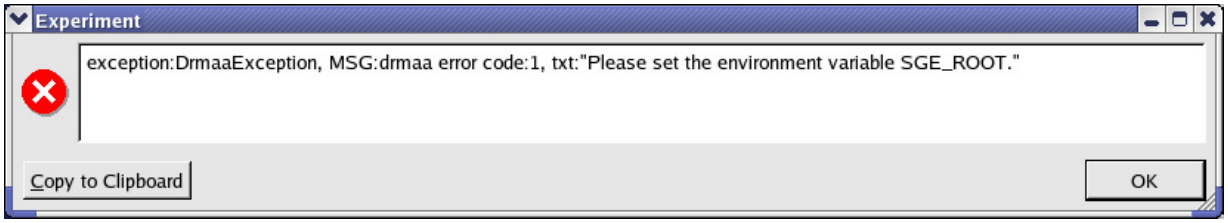

Figure B-15 Error with SGE_ROOT not set

    - **Jobs not executed**. If some or all jobs fail when executed on the Grid Engine, but the jobs still work when executed in the Local queue, this could mean that some (or all) hosts of the Grid Engine cluster do not have read/write access to the VWF fileserver location.
    - **No email notifications are sent although options have been configured**. This could mean that the underlying email system is not configured to allow sending emails. Emails are sent directly from the host, which executes the job. Therefore, every host that is a part of the Grid Engine cluster must be configured to allow sending email.

Note: It is possible to have several profiles for the same queuing system. This is useful if you want to quickly change the set of options that are passed down to the queuing system. For instance, you could have one

profile defining email notifications and another one without email notifications defined. When running experiments with a large number of simulation jobs, you can then select to disable email notifications; whereas for an experiment with a small number of (long running) simulation jobs, you might want to receive notification as soon a simulation job has finished.

B.6 Uninstall Open Grid Scheduler

On the master host, run the following to uninstall all the execution hosts:

```
$SGE_ROOT/inst_sge -ux -host "grid0 grid1"
```

On the master host, run the following to uninstall the master host:

```
$SGE_ROOT/inst_sge -um
```

1. Remove the file:

   ```
   rm -rf $SGE_ROOT/*
   ```

2. Remove the following lines from `/etc/services` on all hosts:

   ```
   sge_qmaster 536/tcp
   sge_execd 537/tcp
   ```

3. Remove the following line from `/etc/csh.cshrc` on all hosts:

   ```
   "source /var/opt/GRID/default/common/settings.csh"
   ```

4. Remove the following line from `/etc/bashrc` on all hosts:

   ```
   "source /var/opt/GRID/default/common/settings.sh"
   ```

B.7 References

For information about the Open Grid Scheduler, please go to:

http://gridscheduler.sourceforge.net/

For information about Oracle Grid-Engine, please go to:

http://www.oracle.com/technetwork/oem/grid-engine-166852.html?ssSourceSiteId=ocomen

Full documentation of (the old) Sun Grid Engine 6.2u5 can be found at:

http://arc.liv.ac.uk/SGE/howto/howto.html

Appendix C
Queuing VWF On An LSF Cluster

C.1 Obtaining and Installing LSF

VWF uses the Distributed Resource Management Application API (DRMAA) to run simulation jobs. This allows you to choose among one of several supported queuing systems. Apart from the Open Grid Scheduler, this version of VWF supports the Load Sharing Facility (LSF).

LSF can be obtained from IBM Platform Computing. Please refer to the installation instructions on how to install LSF on your cluster.

C.2 Selecting LSF to be Used

VWF allows to select, which queuing system to be used. The selection is done by setting an environment variable in the shell, which is used to run VWF. The variable that must be set is called `S_GRID`.

`S_GRID` has the following meaning:

- If unset or set to `"sge"` (without quotes), then either the VWF internal (local) queuing system is used or the Open Grid Scheduler (OGS) is used. Please note, however, that OGS can only be used if a version of OGS was found on your system. If OGS is not found, then the VWF internal (local) queuing system must be used. This system is limited to running simulation jobs on the same workstation that is also executing the VWF GUI. To select the local system, please start `vwf`, open the Preferences panel, and navigate to the **Grid** section. Change the profile from `drmaa` to `local`.
- The variable is set to a value of `"lsf"` (without quotes). VWF tries to use the Load Sharing Facility for executing jobs. If LSF is not found on your system an error message is printed and VWF exits.

Note: If you have been using LSF with VWF before and want to keep on using LSF, then no action is required.

Note: You can have several LSF grid profiles defining various options that are passed down to the LSF queuing system. Figure C-1 displays an LSF profile with options `-L` and `-q` in use. Options `-R` and `-U` are also defined but are not active (not checked).

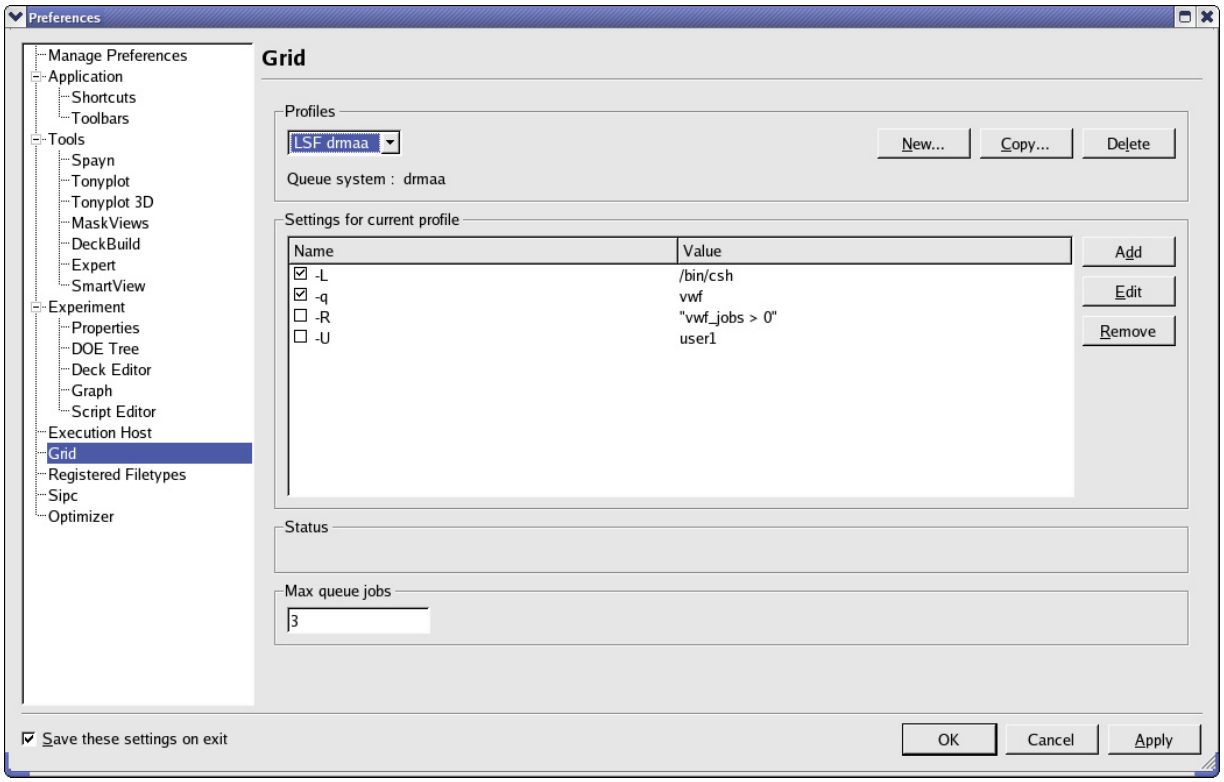

Figure C-1 Options in LSF Profile

Max queue jobs: Use this field to limit the maximum number of jobs, which are added as active jobs into the LSF system. Jobs that would exceed this limit are still added into the system but are put on hold (state PSUSP). As other jobs finish, jobs put on hold will become active and will run whenever the LSF scheduler decides it can run more jobs.

Appendix D
Recommended Practice

D.1 Multi-Threading

Under certain circumstances, an overqueuing/overloading of your system can occur. This can happen if you are using the multi-threaded option of Silvaco simulators. If enabled, a multi-threaded simulator will use as many CPUs installed in a computer system (or as many as specified on the command line). Consider the following scenario of a 4 CPU SMP machine, which will be used with grid engine. The default configuration of grid engine is to allow running 4 jobs concurrently on this host. If each job in turn uses all 4 CPUs, then the load will increase by a total of 16. This indicates that there are now 16 CPU intensive threads running on this host, which most likely was not intended.

Please note that this problem is not limited to running jobs on a cluster like grid-engine but will also occur if VWF is used to run jobs only on a single machine (local mode). Again, overloading can occur if simulators use more than one CPU.

To avoid such scenarios, you should always run simulators in single threaded mode (option `-P 1`) when used from within VWF. If you still want to use the multi-threading option, please make sure that there are no more tasks as there are CPUs in your system that run at any given time.

D.2 Extract Statements

Please make sure that no variables (i.e., `$variable_name`) are used in names for extract statements. The name of an extract is directly used as name for a column in the worksheet. You can only have one such column per extract. VWF creates one row for each value that gets extracted. This is in contrast to DeckBuild, where values in names do make sense and are used to avoid overwriting data between different simulation runs and to tell apart different input parameter settings.

The following example demonstrates a good and a bad case for VWF. The example deck fraction contains an input parameter called length–which is used as a split variable–as well as an `extract` statement to illustrate the usage.

D.2.1 Bad Case (for VWF)

```
set length = 0.1

extract name="Ion_$'length'" y.val from curve(v."gate",i."drain")
where x.val=3.0 outfile="Ion_length_$'length'.dat"
```

If this deck is run from DeckBuild with length parameters of `0.1` and `0.2`, respectively, then extracts named `Ion_0.1` and `Ion_0.2`, and curve files `Ion_length_0.1.dat` and `Ion_length_0.2.dat` will be generated.

If this deck is run in VWF, this would mean two columns in the worksheet, one named `Ion_0.1` and another named `Ion_0.2`. This is undesirable. Instead, there should just be a single column called `Ion` and two rows one with extracted values for a length of `0.1`and another one with an extracted value for a length of `0.2`.

D.2.2 Good Case (for VWF)

```
set length = 0.1

extract name="Ion" y.val from curve(v."gate",i."drain") where
x.val=3.0
```

Above deck can safely be run in VWF. A column called `Ion` will be created in the worksheet and one row per `length` will be created when the experiment is run.

The outfile parameter of the `extract` command is not necessary here. If omitted, it defaults to `results.final` for scalar values and `extract.dat` for curves. It is worth mentioning that while you can have several scalar values in one file (`results.final`), you still need to put every curve in a different file.

D.3 Splitting on line statements in Athena

To split on an Athena line statement, you need to introduce `set` statements and then define the splits on the `set` statements. Below an example deck, which illustrates that

```
go athena


set midpoint=5

set edge=2.5

set left_edge=$midpoint-$edge

set right_edge=$midpoint+$edge

set offset=0.1

set mo_thick=0.05

set igzo_thick=0.03

set al2o3_thick=0.05

set al_thick=0.1


#

line x loc=0.00 spac=0.5

line x loc=$left_edge  spac=0.01

line x loc=5.0  spac=0.1

line x loc=$right_edge  spac=0.01

line x loc=10.0 spac=0.5

#

line y loc=0.00 spac=0.1

line y loc=0.5  spac=0.1
```

In above example, you can define splits on variables (introduced by the corresponding `set` statement) `left_edge` or `right_edge` but not on any of the `line x` or `line y` statements.

D.4 Dealing with Error Scenarios

VWF offers powerful ways of running massive parallel simulation jobs on a network of computers. An important point of the software is therefore to properly diagnose error scenarios so you can take action and avoid or solve the problem at hand.

D.4.1 Dealing with Failing Simulations

It can happen that simulations may fail from time to time. This can be due to the very nature of the simulation task in which case it can only be fixed by changing the underlying simulation deck. The case where **all** simulations fail, however, is usually a systematic problem rather than a simulation related one. The only visual feedback for failing simulations is a red node in the tree pane.

A few hints are given below to help in finding the true cause of a problem.

D.4.2 Standard Output and Standard Error

Every process executing in a UNIX environment has an associated standard output and a standard error stream. These streams are used by a program to print status and debugging information and to report unexpected situations like the disk becoming full or a file, which was not found. This is also true for simulations carried out within VWF. While you are not normally concerned with these streams, you may want to look into both the standard output (contains the runtime output of the simulator) and the standard error, which may indicate additional error conditions.

D.4.3 Extended Job Status Information

The Node Information dialog does not only show simulation result files, runtime output and error information, but will also allow you to look at details like the environment variables that were set during the simulation run or what job limits were applied to the job. You will find this information in the sub-directory called `vwf` shown in the Node Information dialog. You can change into this directory by a simple double-click and then access the shown files from there.

D.4.4 Grid-engine/LSF Jobs Failing

For the case where an experiment runs fine when the built-in queue (Simple Queue) is used, but fails as soon you are using LSF or grid-engine, so please check the environment variables of your jobs. You must supply options to your cluster system to source the shell startup files (`.cshrc` or `.bash_profile`) since these files may contain important changes to your $PATH variable. For the grid-engine system, this option is called `"-shell"` and the argument must be set to `"yes"`. For LSF, the respective option is called `"-L"` and its value must be set to either `"/bin/csh"` or `"/bin/bash"` depending on what shell you want to use.

D.4.5 VWF Background Process not Starting

In rare situations, the VWF background process, which handles execution of simulation jobs, may not start. This is shown by a dialog saying “Starting of general server failed”, which is displayed when you try logging into the database. The problem may have several causes.

It can be an installation issue where the right version of the vwf_server program was not installed on your system. The version of the vwf_server program must be the same as the version of the vwf GUI application. You can check the version, which is used by using the `-WV` and `-WVS` arguments to the `vwf` and `vwf_server` commands as follows:

```
thomasb@lannach$ vwf -WV
2.8.10.R


thomasb@lannach$ vwf_server -WVS
Available versions for this platform are : 2.8.10.R 2.8.9.R 2.8.1.R
2.6.11.R 2.4.15.R 2.2.28.R
```

The output of the first command shows that the default VWF version that is used in your system is 2.8.10.R. The output of the second command shows a list of what versions of `vwf_server` are installed. We can see that 2.8.10.R is one of them. This works fine as vwf and `vwf_server` versions are matched automatically. In this example, if you enter `vwf` without any options, then version 2.8.10.R and `vwf_server` will be used.

Another source of errors may be the shell startup file defining your environment variables (e.g., `.cshrc` or `.bash_profile`).

While the output of the vwf_server process is not directly available from the VWF GUI, you can look into the log-files, which are kept in the `/tmp/vwf_logs` directory. Log-files have dates and process IDs in their names so that you can easily identify the log-file containing the information for your `vwf_server` process.

Note: The location of where the log files are stored can be configured. See Section 2.3.2 “Database Mode” for details.

There are also log-files for the `vwf_daemon` process, which can be found in the `/tmp/vwf_logs` directory. In case there was an error sourcing your startup files, the beginning of the `vwf_server` log file will look as follows.

```
Sourcing .cshrc
setenv: Syntax Error.
ERROR sourcing .cshrc
```

Above citation from the log file indicates that there was a problem in sourcing the script. Note that failing to source the script need not necessarily result in a failing startup of the background process. Other symptoms can be that as soon jobs are being executed, they immediately fail as certain environment variables are missing.

D.4.6 Error Message when Logging into the Database System

When you see an error as shown in Figure D-1, check the setting of Execution host in the preferences panel. It is important that the **local host** radio button is ticked if you are running VWF in local mode (all simulation files kept locally).

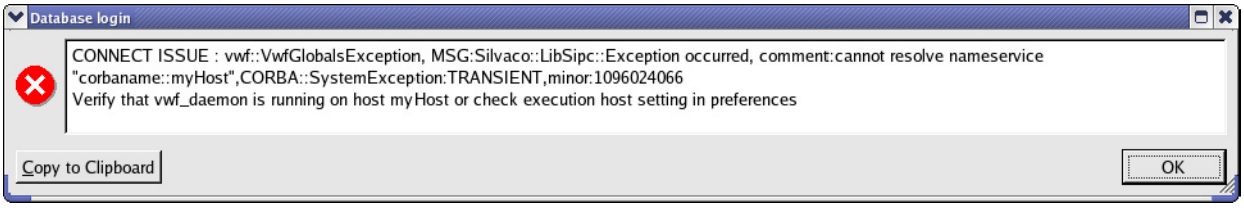
Database login
CONNECT ISSUE : vwf::VwfGlobalsException, MSG:Silvaco::LibSipc::Exception occurred, comment:cannot resolve nameservice "corbaname::myHost",CORBA::SystemException:TRANSIENT,minor:1096024066
Verify that vwf_daemon is running on host myHost or check execution host setting in preferences
Copy to Clipboard
OK

Figure D-1 Login Problem

D.5 Selecting a Different than the Default Version of a Simulator

Sometimes, you may want to use a different version of a simulator as would be run as default. To select a different version, please use the `simflags` argument to the `go` line in the simulation deck. The following example demonstrates how version number 5.18.1.R of simulator Athena is used to run the deck.

In your deck, change the go line to select a version number:

```
go athena simflags="-V 5.18.1.R"
```

Run the experiment. When you look at the runtime output of the node information dialog (opened by right-clicking on a node), you can see the version of the simulator that is being used. This is illustrated by the screen-shot in Figure D-2.

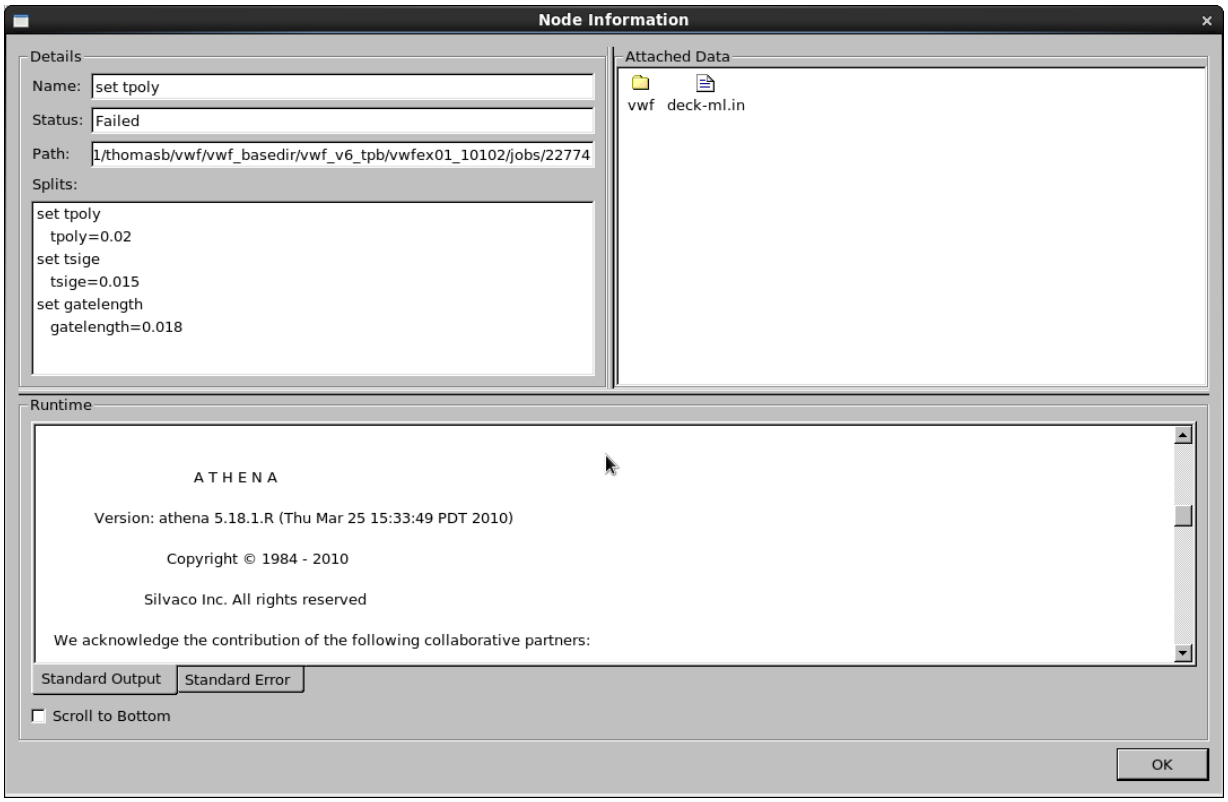

Figure D-2 Node Information Dialog Displaying Simulator Version Information

D.6 Splitting on the Simulator Version

If you want to split on the version of a simulator, you need to use the `assign` statement together with the DBInternal simulator. The following code snippet demonstrates how to split on the version of the SmartSpice simulator.

```
go internal

assign name=myVersion c.value=3.16.12.R

go smartspice simflags="-V $myVersion -P 4"
```

You can then define a split on the `assign` statement and create cells in the worksheet just as with any other parameter. Use the runtime output as indicated above to verify that the desired simulator version is being used.

D.7 Splitting on the Init line of Athena

Note: The following only applies to Athena.

If you want to split on the Athena init line, make sure that the very first fragment always contains an `INIT` statement. This is important so that line statements are handled proper in the very top fragment. You will then need to duplicate the init line in the deck editor and only add split parameters to the second init line rather than the first one. Figure D-3 shows how to do this.

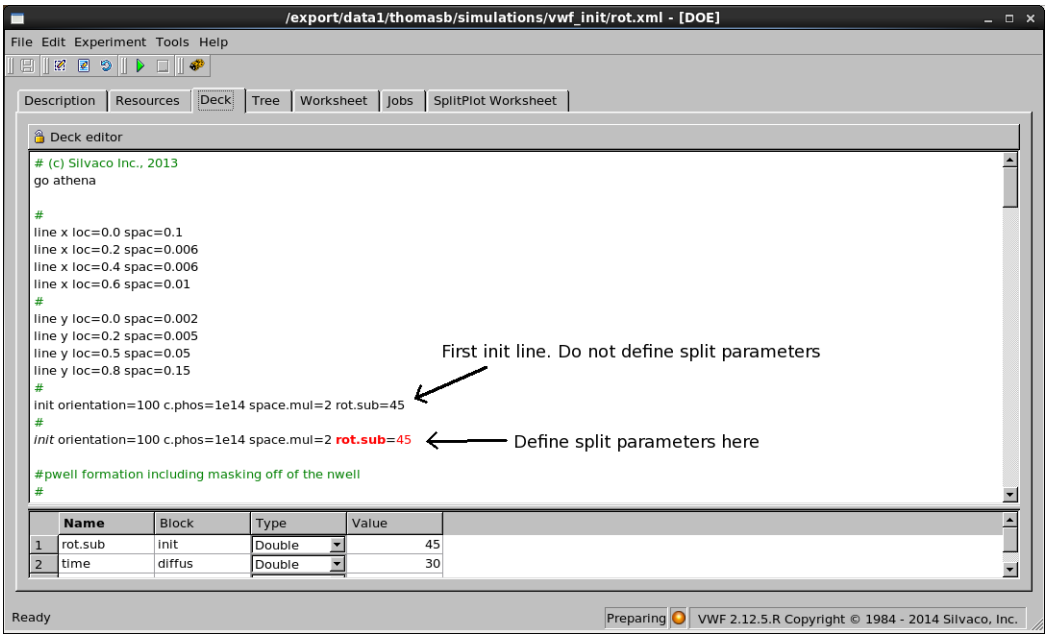

Figure D-3 Splitting on an init line in Athena

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